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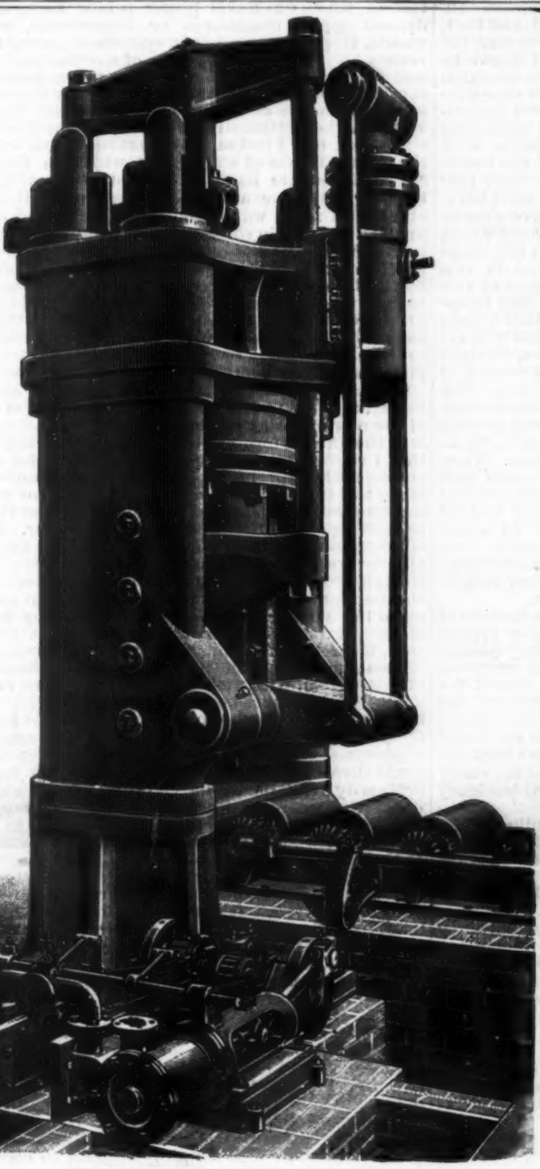
ONE THOUSAND TON HYDRAULIC SHEARING MACHINE.

WE illustrate a fine hydraulic shearing plant, constructed by Messrs. J. Copeland & Co., of the Pulteney Street Engine Works, Glasgow. This plant, which includes a 1,000 ton shearing machine and the necessary engines and accumulator, has been built for the Drumpeller Steel Works, and is intended for cutting steel blooms coming from the cogging mills. The main cylinder of the shearing machine is 36 in. in diameter, and a working pressure of 15 cwt. per square inch is employed, the machine being capable of cutting steel slabs 30 in. broad by 10 in. thick at the rate of four cuts per minute.

The engines have cylinders 18 in. in diameter by 36 in. stroke, and drive, through a cast steel four-throw crank shaft, four single-acting ram pumps, of 18 in. stroke, and 4½ in. in diameter each. The general arrangement of engines, accumulators, and shearing machine is shown in our engravings, for which we are indebted to *Engineering*.



WOODITE.

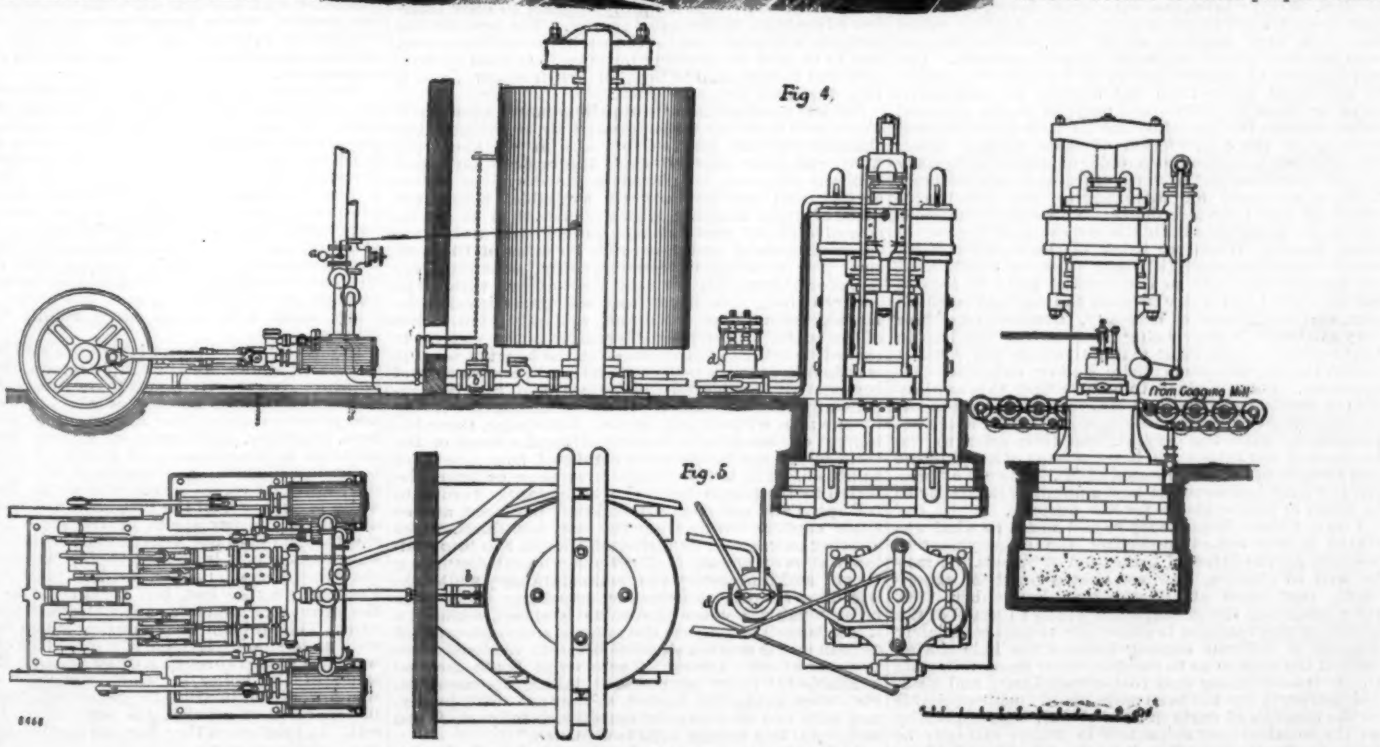
AN interesting paper was recently read by Sir Edward Reed, M.P., at 13 Delahay Street, Westminster. The chair was occupied by Admiral W. H. Colomb, and among those present were Admiral Sir Spencer Robinson, K.C.B., Admiral Lord Clarence Paget, G.C.B., Admiral Sir E. Fanshawe, Admiral Buckle, the Italian and Turkish naval attaches, Captain De Canvos, of the Spanish royal naval commission, Captain Chetwynd, of the Lifeboat Institution, Captain McCulloch, Surgeon-General Munro, C.B., Captain C. A. White, and Mr. F. H. Barnes.

The auther commenced by observing that in a report dated July 22, 1886, he briefly described the nature of woodite—a specially manufactured material, of which India rubber is the principal element, and foretold, with some confidence, its useful application to various purposes. In the comparatively short time which has since elapsed, this material has been adopted with the best results for some of those purposes, and has made great progress toward adoption in other cases, while new forms and applications of the material have likewise been devised by the surprising skill and ingenuity of Mrs. Wood, and appear likely—in most cases certain—to prove of much value, and to be brought into general use. Woodite has proved to be susceptible of production in diversified forms, and appears to be capable of conversion into the finest sheets and ribbons, for use in waterproof articles, or into dense blocks, for resisting the blows of shot or shell, or into engine packing rings, possessing very exceptional advantages. By one process it is converted into a material of a cellular sponge lightness, buoyancy, and flexibility; by another process, during which whalebone cuttings are intermixed with it, it is converted into whaleite, a form of woodite which possesses that rough or frictional quality which is desired in waterproof mats, floor covers for public buildings, stair treads, horseshoe pads, and other like articles.

The rapid adoption of woodite as the material for certain parts and packings of machinery is very remarkable. It is employed in a great variety of valves, and is said by those who have tested it thoroughly, and for many months in succession, to withstand very satisfactorily great heat, high pressure steam, grease, salt water, acids, and gases. It has been employed as packing for engines by several lines of steamships, by the Metropolitan Board of Works at their pumping stations, and in several other public and private establishments. It would be out of place here to quote certificates, but it may not be amiss to remark that Messrs. Grimshaw & Skelton, engineers, of Lambeth, whose inadhesive packing rings are well known, and who have exclusively employed woodite for their purposes, state that they have found it more suitable for packing, cup, and U rings, and also as sheeting, than any other material which has come under their notice, adding, "Woodite possesses, we believe, better properties for withstanding very high pressure steam, great heat, acids, hot grease, salt water, etc., it having stood the several tests and trials for upward of nine months' constant daily use, and in stating this we only express the opinions of all who have tried it."

Valves, etc., of woodite have the great advantage of withstanding the action of bilge water, and also of ammoniacal liquor, and of refuse from gas and tar works. The application of it to the packings of hydraulic rams, for which it is often extremely difficult to obtain leather of uniform thickness, especially when the size is great, has accomplished a very important improvement in this description of machinery, of which the engineers of the Metropolitan Board of Works are largely and wisely availing themselves.

It is a notable circumstance, and one which is, perhaps, mainly due to the fact that these inventions have emanated from the mind of a lady, that all the applications of woodite to naval purposes have



ONE THOUSAND TON HYDRAULIC SHEARING MACHINE.

defensive and protective objects in view. The defense of war vessels against shell fire, the exclusion of the sea from injured vessels, whether for war or mercantile purposes, the obstruction of torpedo and other vicious craft in their attempts at destruction, and the improvement of boats for saving life—all these objects have been set before the inventor, and have been pursued with ardor and with ingenuity not inferior to the humane sentiment which has manifestly actuated them.

The author then continued: I must at this point express my regret that one application of the new material which was dwelt upon in my report of 1886 has not been more promptly adopted in both the royal and mercantile marine. I refer to the proposed introduction of partial bulkheads of this material adjacent to and in connection with the main watertight bulkheads as a means of preventing a single blow in a collision from filling two of the larger compartments of the ship at once, and so causing her to founder. I am happy to say that in some few recent ships more extensive subdivision by steel bulkheads has been adopted, and that, too, at very great expense, but I cannot doubt that the same degree of safety as is thus obtained might be more readily and extensively secured by the adoption of Mrs. Wood's material and of her method of applying it. It is also a matter of great and urgent importance to note that her plan could be applied to existing passenger, troop, emigrant, and mail steamers, at a moderate expense, and with little or none of the inconvenience that would result from the introduction into such existing ships of sufficient additional steel bulkheads to accomplish the same object. I have already made reference to the light and flexible form which woodite takes when produced with a cellular or sponge like structure, and to the circumstance that in this state it is buoyant. Advantage has been taken of this fact to introduce buoyant ropes and cables and to apply these to the defense of war vessels and other vessels against torpedo boats. Even in the elementary form of rope or cable, simply floating on the surface, it might offer great obstruction to torpedo boats, arresting or checking their progress, or fouling their screws. But it is obvious that the most effectual of these devices, that of fouling the screw, may be secured with greater certainty with ropes or cables so arranged as to lie, in part at least, a little below the water's surface. They then allow the bow of the torpedo boat to pass over them, but still lie near enough to the surface to foul the screw. That this is perfectly practicable will be well known to our gallant chairman and to many others, because they are aware that the bow or forefoot of a torpedo boat is less than 2½ feet under water, the keel aft is 3½ feet or more, while the screw propeller sweeps down to a depth of 6 feet or more.

This system of defense has engaged the attention of some European governments, and has been experimented upon at Spezia with very satisfactory results. Woodite cables employed for this and similar purposes can be made to carry with them a copper strand for electric signaling purposes. Any thickness of the wire rope can be made buoyant with woodite, and the flexibility of the finished rope allows it to be recovered by winches when the object of floating it has been accomplished. These woodite ropes and cables are easily handled, being singularly free from the usual tendency of wire cables to kink.

Two or three methods of arranging the fouling cables have been devised: One is that of suspending a non-buoyant cable at short intervals from a buoyant one, so that the former is sustained at the requisite depth from the surface. This was, I believe, the arrangement tried successfully at Spezia. Another is that of making a single cable of varying buoyancy along its length, so that buoyant and non-buoyant lengths may alternate. This results, of course, in the capable floating with a series of submerged loops. Other arrangements readily suggest themselves when once the production of cables with any requisite degree of buoyancy has been made practicable. It is of course very desirable that the buoyant material should not be exposed, as cork is, to saturation when immersed in water, and I am assured that saturation is effectually resisted in this case by the fact that the buoyancy is derived from waterproof cells.

I must say that I regard this particular application of Mrs. Wood's invention with great favor, believing that these flexible and floating or partly floating cables furnish a very valuable aid to the skillful seaman who has to obstruct and avert torpedo attacks. The employment of hollow blocks of woodite as a means of excluding water from the interior of unarmored ships, or from the unarmored parts of partly armored ships, is much facilitated by the improvements effected recently in the construction of these blocks. Their manufacture is now so much under command as to allow of their receiving just so much stiffness as, and no more than, is necessary for withstanding the pressure of water at the intended depth. This consideration is important as regards both the weight and the cost of these blocks. When we think of the number of so-called war ships which (whether wisely or madly need not here be said) are so constructed as to be pierced between wind and water by even the smallest machine gun, and which must of necessity, therefore, owe their very existence to their being more or less filled up in that region by some light material which will exclude water, the importance of these hollow cubes becomes apparent. I am inclined to believe that this application of woodite will undergo still further development, in order to give the block increased stiffness and incompressibility, with less weight, and thus offer to the builders of war ships a still better means of keeping the more fragile of their structures afloat. I do not at present feel confident as to the best amount of flexibility to be given to hollow blocks for this purpose.

I do not think it necessary to add much to what was stated in my report respecting the employment of woodite for the external protection of vessels. It may be well to observe, however, that a practical experiment, performed at Dartford in September, 1886, fully confirmed the anticipation which I formed of the ability of this material to allow shot to pass completely through it without causing leakage, the hole closing behind the shot so as to exclude water from following it. It is astonishing that this extraordinary and valuable property has not been more readily made available in the unarmored parts of men-of-war, more especially as the so-called war ships now in vogue can only be made fairly safe and efficient by the adoption of this or some similar method of excluding the sea from injured compartments. Most of those present are probably aware that since my report was written in 1886 further experiments have been made upon one of H. M. ships with India rubber sheets, with the result that within our Admiralty some gentlemen have concluded that watertightness is not really secured after shot have passed through. It would, in my opinion, be very hasty and ill-advised to draw this inference generally, and to apply it to blocks of woodite of several inches in thickness. From a close examination of such blocks after repeated penetrations, I am thoroughly satisfied that where, as in these, the resistance of the material is allowed to come into full play, the hole so closes after the shot has passed as to make the block as waterproof as ever—proof, I mean, to any such pressure of water as can possibly result from, or be due to, the depth of the block within or upon a ship below the sea's surface.

This being so, and having regard to the immense extent to which our naval power is now being made to depend upon unarmored or imperfectly armored vessels, it appears to me that systems of giving to such vessels the protection of blocks of woodite temporarily and for periods only ought to be taken into serious consideration. It would not be difficult for shipbuilders to devise means of fitting such protective blocks to vessels, either externally or internally, between wind and water, and I feel satisfied that the result would be the saving in war of many ships which, in their present condition, are liable to prompt destruction under the fire of machine and quick firing guns. It is probable that a naval war, attended by a national disaster (such as we seem in some quarters to invite rather than to avert), may be the only thing which will arouse us to a due sense of the value of these saving appliances; but it does seem unaccountable that torpedo boats, and their steel torpedo-boat catchers, should be deprived, even in our present soporific state, of the priceless protection which screens of woodite would afford to them. The same remark may be made as to its application as debris screens in larger vessels of war.

One of the inventions which engages our attention to-day, although not immediately arising out of the use of the new material, has been so closely associated with it in the various forms of boats proposed by Mrs. Wood, that I venture to refer to it here as a matter of very considerable importance. I refer to the employment of central tubes and other compartments for containing compressed air, and to the employment of this compressed air as a motive and propelling power. I know of no reason why this system should not be applied to all our coast lifeboats, and to many others; and, although I have not had an opportunity of working out the amount of propelling power which might be stored up in the whole available space afforded by boats of different types and sizes, I have no doubt whatever that, if carefully developed, the rescuing power of coast lifeboats might be immensely increased by the adoption of this system, with great relief to the severe and prolonged, and ofttimes bootless, physical exertions of that noble class of men who so gallantly man them in times of trial and danger. In most cases of the application of compressed air in this manner for the propulsion of boats there will be no difficulty in applying the labor ordinarily available to the charging of the air chambers. But where that would be difficult, supplies of compressed air can be stored in cylinders at engine stations, or where labor is available, and transmitted to the places where it is required.

Much attention has lately been drawn to steam lifeboats, and many efforts made to produce satisfactory craft of this type, but the production of such craft is beset by difficulties, both as to their construction and as to their employment, few or none of which difficulties oppose themselves to the use of the compressed air system now under consideration. A novel and admirable application of the same idea is embodied in the scout boat for men-of-war, which Mrs. Wood has proposed. Such a boat, whatever her other qualities may be, in order to succeed in night explorations, must be noiseless. It is obvious that, with a suitable engine and propeller, the force of compressed air must be not only more noiseless, but in every way more suitable for this purpose than that of steam. Here, again, we have an invention which deserves the most rapid development, and which certainly appears to offer priceless advantages to the naval service. The inventor has designed a special boat to receive this propelling power, and to be used for scouting purposes. It is an unsinkable and insubmergible boat, of low freeboard, and is thus described by its designer:

"It has a self-contained propelling power equal to 72 knots, and is driven by compressed air, so charged that the boat will run for twelve hours at six knots per hour, and when charged from the engines on board the war ship, can be placed in the davits or on the chocks, and will be instantly available, taking the place of steam launches, which require time to get up steam, and, by their smoke, funnel, and noise, are easily discovered, and discernible for miles on the horizon. For scouting or reconnoitering, searching for mines or obstructions, or taking soundings within the enemy's lines, this scout boat will prove invaluable. Having neither mast nor funnel, and only a few inches of freeboard, it is scarcely discernible in the water. It cannot be swamped or drowned in the heaviest sea. It is noiseless, requires neither steam, coals, nor water, and consequently no increase of weight, and can be propelled by oars if required. It can be managed entirely by one man without any special knowledge, there being but one small lever for controlling the speed of the boat, which can be instantly regulated from one knot to fifteen. The latter, in case of surprise or being detected by the search light, can be instantly turned to full speed and escape at fifteen knots per hour, and so elude capture, while from its size, handiness, great steering power, and light draught, it can run into shallow waters or among obstructions without disturbing them; and if necessary to remain stationary while taking observations, sketches, or soundings, there is no noise whatever when the valve is closed, while in a steam launch or pinnace the noise of steam blowing off as soon as the engines stop has hitherto rendered their presence at once known. These scout boats are also available for other purposes, as taking up moorings, etc., when going into harbor, as they are swift, handy, and with two men can be considered fully equipped and equal to a launch with twelve men."

In the above passage the freeboard is described as being of a few inches only, and this is the case in the form of scout boat there contemplated. But it need hardly be said that all the advantages of the compressed air system of propulsion may be obtained with boats of greater freeboard, and, indeed, Mrs. Wood proposes, I understand, to construct scout boats with turtle-back forecastles and other protections, in order to adapt them for being driven at very high speeds by their compressed air engines. It only remains for me now to state a very interesting fact connected with the specimens of woodite materials and constructions displayed in this room. It is that I am assured on the best authority that all the plans and formulæ upon which the mixtures of materials have been based, and all the rough designs likewise, have been prepared by Mrs. Wood herself, and more than this, for the materials themselves have been practically measured, mixed, and compounded with her own hands, with what complete success we can all see for ourselves.

The chairman having invited comments upon the paper, an animated discussion ensued, in the course of which there was a triangular duel between Admiral Sir George Elliott, Sir Spencer Robinson, and Sir Edward Reed, upon armor-plated ships. The result was a mutual agreement that the woodite apparently offered the medium of protection desired, and a verdict of approval of its invaluable properties for defensive purposes. Captain Chetwynd discussed the matter as to its applicability to lifeboats, and in the course of a searching cross questioning as to the seagoing qualities of Mrs. Wood's lifeboats, of which models were exhibited, elicited very valuable evidence in favor of their adoption, and invited applications from Mrs. Wood to the Lifeboat Institution, promising such the fullest consideration.

HEATING CITIES BY STEAM.*

By CHARLES E. EMERY, Ph.D.

THE advantages of a steam supply from a central station for the buildings in a city or village, and even for the detached buildings of hospitals and other public institutions in a park, are very evident, and such a system has, in the past, been many times suggested as desirable. About fifteen years ago, Birdsall Holly, of Lockport, N. Y., made experiments in his yard to show the loss of heat in transmitting steam through an underground conductor, the outcome of which was the design of a practical system adapted for street distribution, in which stuffing boxes were arranged at regular intervals of about 100 feet, and anchored fast, so as to preserve their location and permit the sliding sleeves to move in and out freely, in line. Outlets were also provided in chambers back of the stuffing boxes for the attachment of service pipes to distribute the steam to buildings, so the supply was from stationary points the same as if boilers were located at such points. Simple as these improvements seem to have been, compared with previous arrangements of interior steam piping, they form an important element of the success of modern systems of steam distribution in cities. The large steam plant of the New York Steam Company has been built up, under the direction of the writer, on the principle in the Holly patents, above described, but without the use of one of the Holly details, and the steam from boilers of 12,000 horse power is now being delivered at a pressure of eighty pounds and upward for power, as well as heat, through some five miles of large steam pipes, some of which extend three-fourths of a mile from the boiler station.

It is proposed to discuss the general features of what is technically called a district steam system, and to introduce in connection therewith brief descriptions of the work of the New York Steam Company, illustrated by drawings of the principal details used.

A district steam plant is in some respects similar to, and at first sight would appear to be only an enlargement of, the method of distributing steam from a central point to the buildings of a large factory or public institution. In fact, however, the conditions encountered in putting pipes in streets already full of underground obstructions, such as other pipes, vaults, sewers, etc., in such a manner that consumers can be accommodated when and where desired, involve many more difficulties and require many modifications in detail compared with a system where all the property is under one control, where space underground is rarely obstructed or valuable, and where the whole plant, with all its ramifications, may be laid out before the work is commenced.

The nature of the difficulties encountered in transmitting steam for a considerable distance are not generally understood. Condensation necessarily takes place, as is expected, but non-conductors may be applied to reduce this loss to so small a proportion of the carrying capacity of the pipes that it will not form a serious disadvantage in a mere commercial sense. The problem may be called difficult on account of the number of principles involved and the mass of engineering and mechanical details required to apply the principles correctly and successfully. Condensation is but one of the many conditions to be provided for, and in some respects an embarrassing one, but it can be satisfactorily dealt with much more readily than several others.

Dry or saturated steam is well adapted for transmission to a distance, for the simple reason that the temperature always corresponds to the pressure. The laws of thermodynamics show that absolute temperatures and pressures alway bear a constant relation. It follows, therefore, that steam of a given pressure is as valuable at the distance of a mile or more from the boiler in which it is generated as it is at the boiler itself; also that steam mixed with water has, when the water is removed, all the properties and is equally valuable as any other steam of the same pressure. In short, steam does not *deteriorate* the least in transmission, so long as it is steam; that is, has been freed of the water of condensation incident to its transmission. Pressure may be lost, but permit me to repeat that the steam is as valuable as any steam of the same pressure. The problem of separating steam from water is well understood. Evidently if a mixture of steam and water be passed through a drum as large as the steam space of the boiler in which the same quantity of steam would ordinarily be generated, the water will be separated by gravity, the same as in the boiler itself. In most cases the pipes themselves act as drums

* A lecture delivered before the Franklin Institute, November 18, 1887. From the *Franklin Journal*.

In any case, by a proper application of principles, it is possible to transmit steam to as great distances as any other fluid. The actual maximum distance must be governed by commercial considerations as to relative cost of piping and stations. To make steam efficient, then, it is necessary only to maintain the desired pressure at the ends of the lines, and this depends upon the size of the pipes and the loss of pressure that can be permitted.

The first problem in designing a steam plant is to ascertain the total quantity of steam required and the quantity necessary to supply in detail the several blocks on each of the streets through which the pipes are to be run. In New York this was approximately obtained, first, by collecting the statistics on file in the police department, with relation to the steam boilers in place in the city, rules being given the computers by which the approximate power of a boiler could be determined from the external dimensions and type, which were the only dimensions taken by the boiler inspectors and reported to the police department. The aggregate cubic capacity of all the buildings within the areas which it was expected to heat were also computed approximately from the insurance maps, and this multiplied by a proper factor gave the estimated quantity of steam required to heat that space. This preliminary work, although simple in its character, involved a great deal of labor, on account of the number of streets, buildings, and boilers to be considered.

The first station of the company was located on Greenwich Street, between Dey and Cortlandt Streets. The building was designed to contain 16,000 horse power of boilers of the Babcock & Wilcox type, and will be illustrated and explained hereafter.

In all, propertities were purchased for ten stations in different parts of the city, but of these but two have as yet been constructed, viz., the one mentioned at Cortlandt and Greenwich Streets, designated as station "B," and an inside or temporary one at Fifty-eighth Street and Madison Avenue.

Some idea of the magnitude of the work can be obtained from the statement that there are already in position in the first station one sixteen-inch pipe, one fifteen-inch pipe, and one eleven-inch pipe, with only part of the capacity of the building yet utilized, and that it is expected to put in in addition one thirty-inch pipe to keep up the pressure at a distance as the demand increases.

Considerable investigation was made to ascertain the proper formula for determining the sizes of pipes required to transmit the steam. The difficulty was not so much in finding formula as to decide which were best applicable. As is generally the case, the simplest was finally determined upon, based directly upon the laws of falling bodies, and in form that generally used for the flow of water in pipes, simply substituting for the density of water that of steam at the pressure to be carried. Most of the experiments on the flow of gaseous fluids given in the text books refer to air at low pressures and with very small quantities of discharge. There were, however, some experiments on the flow of compressed air in the pipes supplying the drills in the Mont Cenis tunnel, where the pressure and quantity of air moved were sufficient to compare favorably with the conditions under which steam was to be transmitted. By substituting numerical values determined from these experiments in the ordinary water formula with a character representing the density introduced, a general formula was obtained in which the constant very curiously and satisfactorily coincided very closely with those given by Wiesbach, in relation to the flow of air at about the same velocity as was expected in the steam pipes. It should be observed that the loss of pressure due to transmission varies also with the density of steam, so that any formula founded on a constant density is not precisely correct. As, however, the loss of pressure was to be restricted to ten pounds, the original formulæ were based on the average density. At a later date, however, investigations were made in which the variations in pressure were taken into consideration; the formula derived from the water formula being considered a differential formula with relation to the flow of steam. By this means a formula was obtained which, it was believed, well represented the probable facts for all steam pressures, and all losses of pressure in transmission. Between the limits of pressure it was expected to use in practice, it was found that practically one formula was as exact as the other, so the use of the simpler one was continued for general use. When the slope was introduced in the formula, to wit, ten pounds per one half mile, and the density which was first fixed at that due to seventy pounds, with the expectation of going from seventy-five pounds down to sixty-five, the formula for the weight of steam discharged per hour reduced at once to

$$W = 87{\cdot}3\, d^{\frac{5}{2}}$$

d being the inside diameter of pipe in inches.

This form results from the fact that the areas of the pipes vary as the squares of their diameters, and the hydraulic mean depths which are proportioned to the friction as the square roots of the diameters, so the products of the two vary as the $\frac{5}{2}$ power. For strict accuracy some modifications should have been introduced in the formula, as the friction undoubtedly reduces as the velocity increases, and it is probable also that the friction reduces faster than the hydraulic mean depth. It was not necessary to consider these points, however, as the variation in velocity and density were so small. In practice it was not found expedient to reduce the pipes as rapidly as the mere conditions of demand, according to the maps above referred to, would indicate. It was thought that possibly there might be a concentration of demand on certain lines, and it was also desirable to make provision for re-enforcing the pipes near their ends from other stations should it become necessary. Consequently, in practice, only the lines leading to the boiler house were proportioned by the rule, and the others as a general thing were made larger. It was not thought best in the down town streets to lay any steam pipe less than six inches in diameter throughout the length of a long block, and although this was small by calculation for some blocks, still, as it could be fed at both ends, it was considered sufficient, and has since so proved in practice. The above formula was designed to carry the whole capacity of the pipe to its end, whereas in practice steam is being continually drawn off, thereby enabling the remaining quantities of steam to be carried along with less relative reduction of pressure. On the whole, therefore, considering the various conditions, it was decided to increase the value of the constant in the formula to an even 100, and the table of the carrying capacity of pipes now used is simply derived by raising the actual internal diameter of the various nominal sizes of pipe in inches to the $\frac{5}{2}$ power, and carrying the decimal point two places to the right.

It is found in practice that steam pipes can be so protected that the loss of condensation will be a very small proportion of their carrying capacity. Experiments were made before the plant of the New York Steam Company was built, which showed that mineral wool, of ordinary quality, furnished very nearly the same resistance to the passage of heat as the same thickness of hair felt, and that the better qualities were equal or even superior in this respect to hair felt. As mineral wool is non-combustible, quite permanent when kept dry, and not subject to friction, and withal could be manufactured quite cheaply, it was fixed upon as the material to insulate the pipes of the New York Steam Company.

In a majority of cases the pipes were suitably supported in the bottom of a trench, brick walls built up at either side, and covered with planking and roofing material, as will be illustrated hereafter, so as to leave a space of from three to four inches about the pipe on all sides, in which mineral wool was placed in bulk. In some cases the wool was placed inside of wood casing of pump logs, but this was not considered a part of the regular system, and has not proved as desirable or durable as the other plan. The result of this method of covering has been that with nearly five miles of large pipes, also about two miles of smaller pipes used as services, all under steam continuously, days, nights, and Sundays, there was required but 150 horse power each of thirty pounds of water per hour, to supply the condensation in the mains. The mains vary from sixteen inches in diameter to six inches, and the services are mostly three inches in diameter. This loss is so small, as has been previously stated, that it does not affect seriously the commercial problem of the transmission of steam. The water of condensation, however, though limited in quantity, must be properly provided for. If in all cases steam could be transmitted at slow velocities in a large pipe, graded so as to have a slight descent *away from* the source of supply, the water in the steam would separate by gravity, and trickle along the bottom of the pipe, the size of the stream of water gradually increasing until means were provided to permit its escape. By taking the stream from the top of such a pipe and arranging to blow out the water at intervals from the bottom, the length of the pipe could be continued indefinitely, no inconvenience would result, except the loss of pressure due to the distance, and the steam at any point would be as dry as though it came from the boiler direct.

This ideal state of facts is accomplished as nearly as possible in practice. Steam must at times be carried up a slope instead of down, and frequently the pipes must have undulating grades to correspond substantially with those of the surface of the ground. When the movement is up a slope, the water of condensation is, to a greater or less extent, entrained by the current of steam. This is particularly the case when the steam is moving at a high velocity. In practice the up grades, in the direction the steam is transmitted, are made as sharp and as short as possible, and beyond the summits, the down grades, in which there is a natural separation of the steam and water, are made easy and long. This desirable arrangement cannot always be carried out; the street obstructions are frequently so arranged that the pipe can only be laid in undulating grades corresponding more or less to those of the surface.

In all cases, arrangements are made to trap out the water of condensation at the bottom of every dip of the pipes, so that the current of steam passing onward and upward has no more water to contend with than is condensed in the portion of the pipe to be passed over. The water is removed automatically by a steam trap, and returned to the boiler house through another system of pipes, called return water pipes, the details of which, as well as of the traps, will be referred to hereafter.

The expansion of small pipes is generally provided for by means of bends and offsets, which will spring sufficiently. This method, in its simpler form, is applicable to short lengths only, but if the arrangement be well-studied, pipes of any length may be laid on this system. For instance, if it be desired to run a pipe from one end of a long building to another, it may be accomplished by crossing and recrossing a sufficient number of times. No known rules for this kind of work are formulated. The workman is supposed to make the offsets of such a number and with such lateral lengths that expansion will not strain the joints. Frequently, however, insufficient attention is given to this matter, and leaks are developed at important fittings, which it seems impossible to keep in repair, and the work can only be made satisfactory by changing the system to suit the actual conditions. A modification of the offset system with what are called swinging elbows forms a much safer method of providing for expansion, but is less used, as more fittings are required, and some little study is necessary to adapt the work to the straight lines and flat grades necessary in a building. It is, however, a very desirable way of laying long pipes of limited size underground and elsewhere where the grade can be changed as required.

Swinging elbows are also used to pass obstructions, such as cross pipes, which can be inclosed in a yoke in the steam pipe. The steam takes the upper part of the yoke, the water of condensation the lower, and drainage is not interfered with.

Stuffing boxes or slip joints are frequently used on long lengths of pipe to provide for expansion, though generally on large pipes only. This system answers very well for water pipes, or where the steam pressure is low. With high pressures, the packing has to be very compact to resist the pressure, and great care and some considerable expense are required to keep the stuffing boxes in order and prevent them from leaking. Frequently stuffing boxes are applied without due care in anchoring the pipe. Cases have occurred where pipes were prevented from sliding simply by a lateral connection coming in contact with the side of an opening in a wall or partition. In laying a number of stuffing boxes on a length of pipe without anchorages, the whole pipe may shift to the box which is loosest, and the others may not move at all until the first has a very extreme movement, or, as has sometimes happened, is pushed entirely in. Sometimes, in cooling such a system, the sleeve of one stuffing box is pulled entirely out of the packing.

The original street system of Birdsall Holly, who used anchored service stuffing boxes at frequent intervals, has already been referred to. The value of his system is best exemplified by briefly describing a modification of it used by a company in the city of New York, started in opposition to the work of the New York Steam Company, soon after the latter was well under way.

In the case referred to, stuffing boxes were used, but they were located only at the corners of the streets in castings, which also served as crosses to connect with the main street laterals. The consequence was that expansion had to take place for the whole length of the block, and this system was carried out whether the blocks were 100 feet long or 400 feet. The pipes were carried on rollers, so that they would move freely. If mere expansion and contraction had been all that was to be provided for, the system would have worked well enough, if properly constructed.

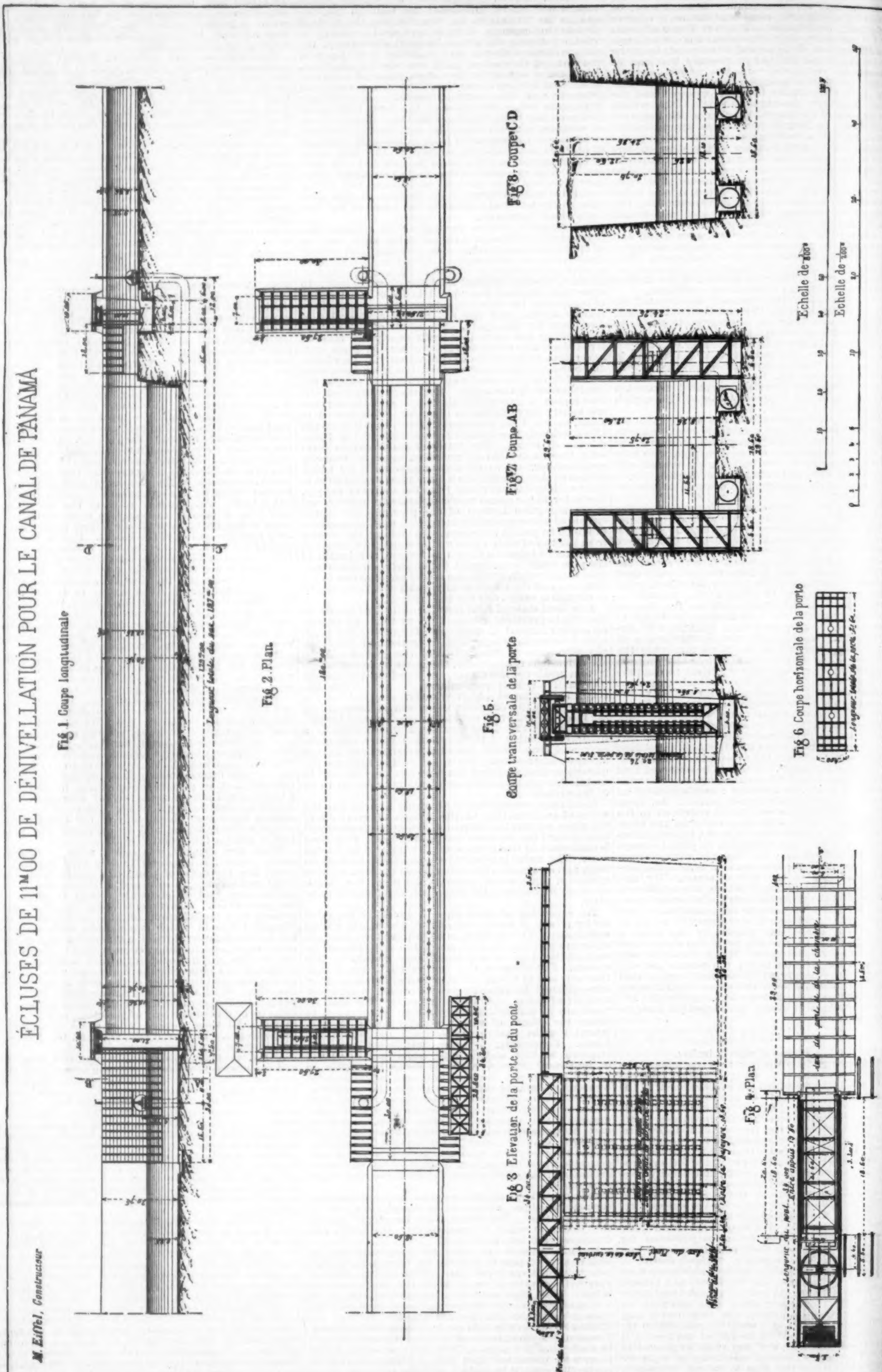
In all cases, however, in street work, the grade and line must be changed at intervals to avoid obstructions. These were overcome in this particular case, even for pipes eight inches in diameter, by making rigid offsets, sometimes of several feet, with common screw elbows. The friction of the stuffing boxes was so great that leaks soon developed in the elbows of these offsets, and in one or two cases the elbows actually broke, letting the steam freely into the ground, and causing what were termed explosions. Moreover, the pipes, which were supposed to be nearly straight, did not always move freely in the stuffing boxes, from the great difficulty in setting the stuffing boxes exactly in line with the pipe. It was very difficult to keep the stuffing boxes tight, and the manholes in which they were located were so hot that the men became exhausted in attempting to attend to the packing. In this system the services were taken from independent pipes anchored only at the street corners, and running for the length of the block, it being expected that there would be spring enough in the various laterals entering the house to allow for the expansion due to the length of half a block. As, however, some of the blocks were very long, it became necessary to leave considerable space in the boxing around the lateral pipes, particularly near the centers of the blocks. During the early part of the work, when steam was turned on and off frequently, the fitters would sometimes allow for expansion one way and sometimes the other. They were at first accustomed to allow for a movement of the pipes from the nearest street corner as it was heated up. When the pipes were already heated, they thoughtlessly, at times, left the room on the same side, for which reason, when the pipe was shut off, the contraction would cause the service to strike the boxing, which produced leaks, and, in some cases, rupture.

In one case, where connections had been made when the pipe was heated, the service was sheared off as the pipe cooled off, which was not known until steam was again turned on, when the lampblack used for insulation was blown all over the building. In one case of this kind, a break occurred on shutting the pipe off, and in repairing the break, the fitter allowed for contraction instead of expansion, without noting that the pipe he connected to was then cold, and the same service pipe was broken a second time when the street pipe was again heated. The wisdom of Holly in arranging that the fitters should only have distances of half a hundred feet to provide for by offsets, instead of half a block, could not be more forcibly illustrated. It is almost needless to say that the system in which the stuffing boxes were placed only at the street corners proved an utter failure, and its operation was discontinued after a few months' trial.

When the speaker was called upon to design a steam system, it appeared to him very desirable to avoid the necessity of using slip joints, with their leaks and expense in care and attention, and it was readily seen that an elaborate system of offsets was not practicable. Experiments were, therefore, commenced with modifications of what are known as diaphragm joints, in which two annular disks of metal are bolted together through a separating ring at their outer edges, and the inner edges bolted to the ends of the lengths of pipe, or a single disk is bolted at the periphery to a large chamber connected with the pipe on one side, and the center of the disk to the pipe on the other. With these joints, the elasticity of the disk permits limited expansion; the movement causing the disks to be dished one way or the other, as may be arranged. All these devices, when made as ordinarily proportioned, proved too stiff, and had too limited a range for use in a street system.

A trial was made with cast iron pipe, cast very thin and corrugated very deeply, it being hoped that each pipe could be corrugated sufficiently safely to provide for the expansion of its own length. In such cases it was proposed to put in a lining of thin iron to form a smooth passage for the steam. These experiments made it doubtful if the plan would succeed, even if the pipes were corrugated the entire length. Although the cast iron was elastic within a certain limit, the great difficulty in obtaining uniform thicknesses made breaks liable to occur unexpectedly. Experiments with several plates held at the inner and outer edges were more satisfactory, but as ordinarily proportioned were too stiff, and had too little range of movement for the purpose.

If the disks were originally dished in one direction with a view of forcing them first flat and then to dish them in the other by pressure, they were, of course, very much stiffer. Improvements were made by reducing the thickness of the plates and corrugating them annularly, but even when the plates were made of soft steel corrugated annularly as aforesaid, and six inches free space left between the inner and outer flanges, the plates still proved too stiff, so that there was danger of breaking the joints on the pipes to move the expansion joints, and it was not thought practicable to use more than half an inch movement for each of such diaphragms. Diaphragms of this kind were actually dished from one-half inch in one direction to one-half inch in the other, making a movement of one inch, but some parts of the disk developed a tendency to stiffen sooner than the rest, and the movement could not be



THE PANAMA CANAL—THE LOCKS DESIGNED BY M. EIFFEL.

made back and forth a number of times without disturbing the symmetry of the disk. The improvement due to reducing the thickness was, however, so great that the suggestion came to mind that if the plates could be still further reduced with safety, the available deflection would be inversely as the cube of the thickness, and sufficient movement could be obtained.

A successful expansion joint was finally made by using disks of copper less than one-sixteenth inch thick (0·04 being finally settled upon), corrugated concentrically and supported on radial backing plates, which prevented the diaphragm from being distended to rupture by the pressure.

Elaborate drawings of this device are shown upon the screen; one, called a double variator, having two diaphragms and providing for expansion from two fixed points on either side fifty feet away; the other, called a single variator, having but one diaphragm, and providing for expansion from one direction only. The services are taken from the bodies of these variators. The outlets are provided with flanges, but are plugged in the first instance, these plugs being removed as required with steam pressure in the mains by bolting a valve to the flange and removing the plug through it, by means of a special tool seen on the screen. The stems of the valves are extended to the surface of the street, and may be operated through suitable openings in castings placed between the paving stones. At regular intervals of about fifty feet the pipes are connected by means of ball joints, which enable the direction to be changed slightly and take out the strain. Both the ball and plain joint flanges are made tight by the use of gaskets of thin copper corrugated annularly, which squeeze into every irregularity of the surface and become absolutely tight, even without the use of paint or putty. Pipes of six inches in diameter or less are screwed into the fittings. Larger pipes (and some have been used as large as sixteen inches in diameter) are rolled into the flanges and fittings with an expanding tool. The ends of the pipes abut against shoulders, and the faces against which the expansion takes place are slightly dovetailed. The variators are provided with boxes, which cover the connecting flanges and terminate in cylinders of metal, which are built in the brickwork surrounding the variators. The various crosses, tees, and other special fittings required are necessarily made of a substantial character to resist permanently the steam pressure of eighty pounds. The bodies of the crosses and tees are made globular, to better resist the strains to which they are subjected.

Wherever a valve is placed in the pipe, or a line is terminated, heavy anchorage castings are abutted against the flanges in the pipes and masonry built against the castings with wings well spread out, to engage with as much of the surrounding soil as possible, and thereby hold the pipes and fittings rigidly in position. Two lines of mains were run originally, one for steam, the other for the return water of condensation. Generally the latter main is laid lower than the other, so that the outlets of the two mains will pass each other. On Fifth Avenue, where there is rock excavation, with large water pipes lying at one side, the bottoms of both mains are put on a level, and the side outlets take out below the level of the mains, through what are called "drop crosses."

The traps used by the New York Steam Company are seen on the screen. They are of the bucket variety, with valves of different kinds, according to the size, operated directly by a float, or through the intervention of levers. Two forms of regulating valve were described. In one, the Curtis valve, the reduced pressure operates upon a diaphragm, which through a secondary valve admits steam to a piston operating the main valve. Another valve is shown in which the reduced pressure acts directly upon a piston connected with the valves and balanced by external weights or springs.

(To be continued.)

THE PANAMA CANAL—THE LOCKS DESIGNED BY M. EIFFEL.

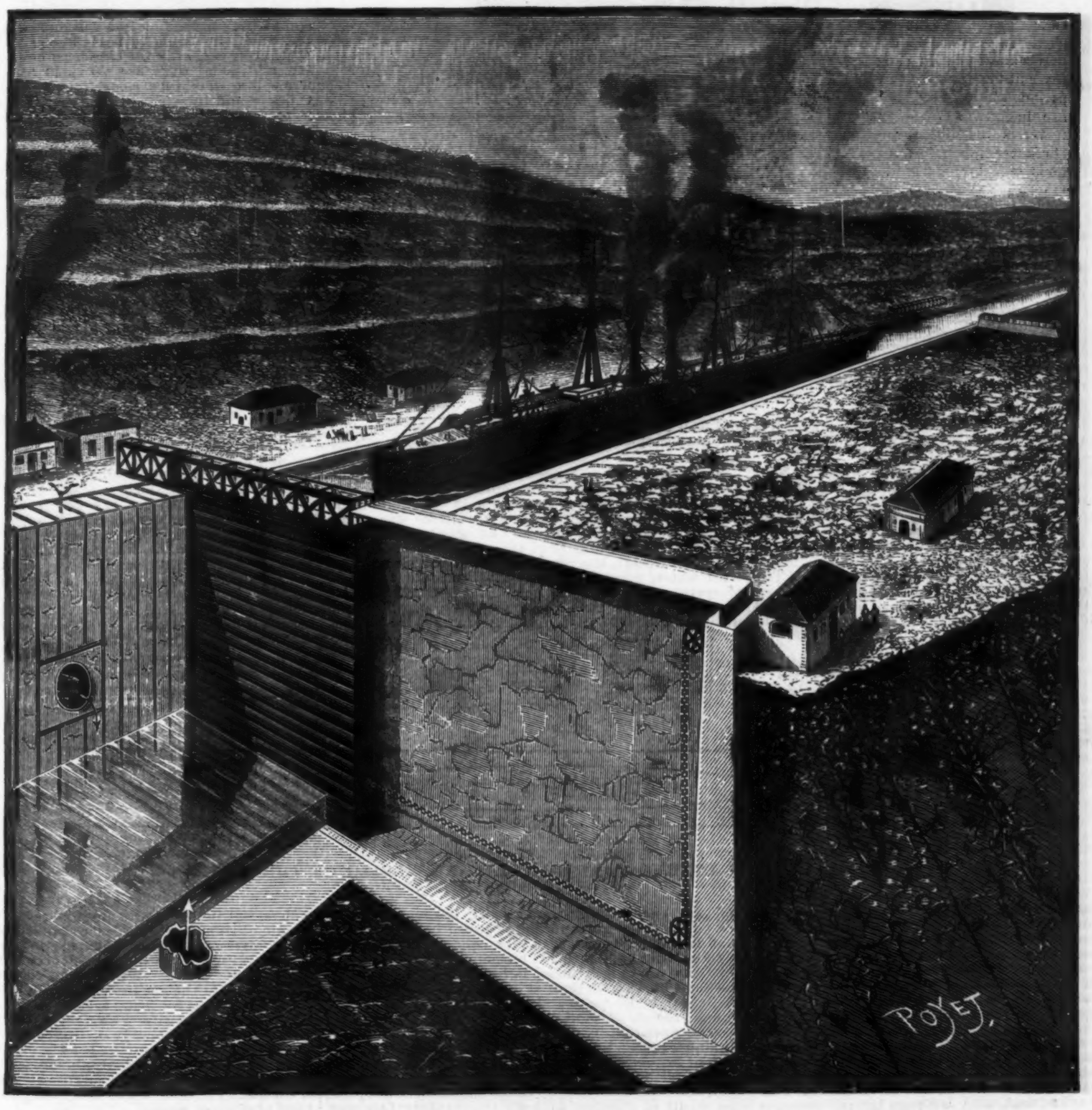


FIG. 1.—LOCKS OF THE PANAMA CANAL—FLOOD GATE OF 11 METERS FALL.

THE LOCKS OF THE PANAMA CANAL.

WE illustrate herewith the new system of locks devised by Mr. Eiffel for use on the Panama canal.

The gates (Figs. 1 and 2) consist essentially of a hollow, balanced movable caisson, capable of sliding above at right angles with the axis of the canal, on a track carried above the canal by a revolving bridge. This track is prolonged above the lateral chamber. The motion is analogous to that of the doors which slide at the top that are generally used in locomotive shops. When the flood gate is placed in the chamber, it is only necessary to revolve the bridge 90° to free the passage and allow boats to go through.

The diagram in Fig. 3 shows the maneuver. A vessel, S, is about to pass from lock, B B′, to the reach, C. To this effect, at N the gate, P′, taken from its chamber, R, bars the canal, and the bridge, A′, is closed above it. At M the gate, P, has slid into its chamber, R′. The revolving bridge has pivoted 90° and opened the passage.

The gate or movable caisson, the sides of which are stiffened from meter to meter by strong, horizontal T shaped iron beams, which carry all the stress of the water pressure over to the side walls, is arranged beneath like the working chambers of the caissons used in constructing bridge piers. Moreover, above the working chamber, it is divided into nine compartments by three horizontal and three vertical partitions. All these compartments, as well as the bottom chamber, communicate with the external air through chimneys starting from air locks, so that either water or compressed air may be allowed to enter them at will. Owing to this arrangement, it is easy to balance and ballast the gate, and, besides, on exhausting its different parts in succession, to inspect and repair them. The gate is suspended from a carriage provided with rollers, which, on rolling over the track carried partly by the bridge and partly by a framework, carries along the gate.

The suspension rods of the gate are not fixed in an invariable manner to the carriage. They carry rollers at their upper extremities which are capable of revolving to a certain distance upon transverse rails fixed to the carriage. The object of this arrangement is to start the gate before sliding it forward and to prevent its rubbing against the walls of the chamber and its bearing points. The gate remains constantly suspended by parts situated outside of the water, and which can be repaired and kept in order with the utmost ease. This mode of suspension offers the advantage that it assures the complete stability of the gate, even under the influence of winds that might be capable of overturning it. For a lock of 11 meters fall the dimensions are as follows:

TAIL GATE.

Height	21	meters.
Width	4	"
Length	21·6	"

HEAD GATE.

Height	10	meters.
Width	3	"
Length	21·6	"

For the lock of 8 meters fall, the height alone varies. The section of the canal left free by the opening of the gate is 18·6 meters at the lower part and 20·6 at the leveling of the talus and works of access. The location for the locks will have to be so selected that they can be excavated in compact rock. The side walls of the intermediate locks will then consist of the rock itself, with a thin lining in places where there are cracks. As

for the side walls of the heads, they will be formed of T iron caissons lined with cast iron and filled in with beton. Their dimensions vary with those of the locks. For a lock of 11 meters fall they are as follows:

Thickness	5·5	meters.
Height	24·25	"
Length	30	"

The revolving bridges are of iron or steel, and are

FIG. 2.—THE GATE OPEN.

5·5 meters in width by 34·2 in length. This length is divided into two sections of 23·8 and 10·4 meters on each side of the axis of revolution.

The gate chambers are 7 meters in width by 30 in length. The maneuvering of the bridges and gates is effected through chains winding around capstans actuated by hydraulic power, through turbines moved by the fall of water occasioned by the reaches.

In order to introduce so great a mass of water in so short a time (40,000 cubic meters in 15 minutes), it has been necessary to adopt peculiar arrangements. The method adopted consists in making the water flow through the entire length of the lock and in vertical jets, so as to prevent the strong eddies and tumultuous

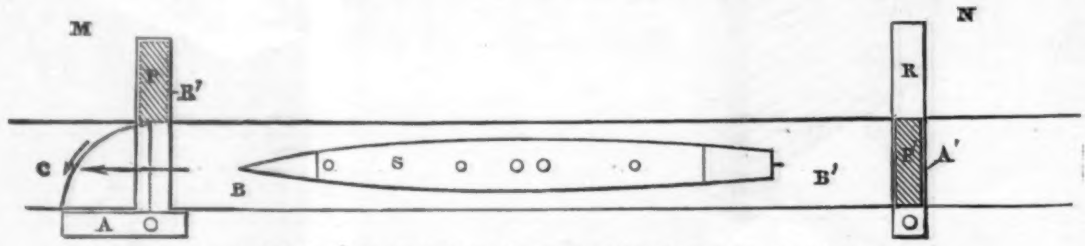


FIG. 3.—DIAGRAM EXPLANATORY OF THE MANEUVERING OF THE GATES.

motions that would necessarily be produced in this arrangement. To this effect, for the entire length of the lock, and laterally, in channels beneath the flow of the canal, there run two large cast iron pipes 2·8 meters in diameter, provided at every two meters distance with 0·40 meter apertures. These pipes pass beneath the sill of the gates, at each extremity, and are prolonged about 15 meters down stream and about 12 up stream in the reach that follows the lock (Fig. 4). Here they curve, and, at 9·75 meters above the floor, terminate in a valve contained in a chamber formed in the side wall. There are, then, two valves of this kind to each reach. These valves, due to Engineer Fontaine, are cylindrical, and without lateral pressure,

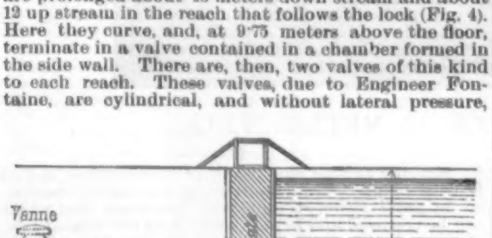


FIG. 4.—POSITION OF THE PIPES FOR FILLING THE LOCKS.

thus rendering the maneuvering of them extremely easy. With this system the emptying and filling of the locks will take but a quarter of an hour.

For the illustrations and description of these gates we are indebted to *Le Genie Civil.*

GAS FIRED STEAM BOILERS.

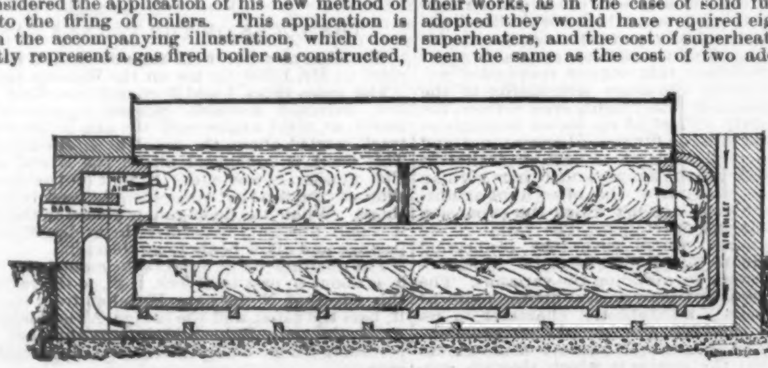
AT the September meeting of the Sanitary Congress at Bolton, papers on boilers were read by Messrs. Fletcher, Duncan, and Orvis. During the discussion on these papers, Mr. John Head explained and illustrated the system of gas firing for steam boilers recently perfected by Mr. Frederick Siemens, and as this subject, though not absolutely new, is yet of great importance and well worthy the attention of steam users generally, we publish herewith an abstract of Mr. Head's remarks:

Mr. Siemens, when considering the action of gaseous flame in a furnace heated by contact, came to the conclusion that the flame was misapplied. He found that combustion was disturbed and the flame was partly wasted when brought into contact with any solid substance whatever, and that this was particularly the case with boilers, the plates of which, being in contact with water, must necessarily and constantly be at a temperature considerably below that of the flame. Mr. Siemens inferred that a gaseous flame, in order to be utilized to the best advantage, should burn freely in an inclosed space without contact with the materials under treatment or surrounding objects; in other words, that it should be placed under conditions analogous to those which apply to gas burners. If we consider a gas flame used for artificial lighting, say an Argand or flat-flame burner, we shall at once realize how undesirable it would be to introduce therein any solid substance; the result would be loss of effect, which would become apparent by diminution in the light and heat obtained, coupled with the production of smoke. Expressed in this manner, it becomes evident that contact of flame with solid substances is detrimental to combustion; and where heating by radiation has been adopted, the result of practice in high temperature furnaces, such as are used for the production of steel on the open hearth, for heating iron and steel, for the manufacture of glass, and other purposes, has been a saving of from 30 to 40 per cent. in weight of fuel, improvement in the quality of the product, and diminished wear and tear of furnaces.

With these encouraging results before him, Mr. Siemens considered the application of his new method of heating to the firing of boilers. This application is shown in the accompanying illustration, which does not exactly represent a gas fired boiler as constructed, but is only intended to show the means adopted for preventing contact of flame with the plates in the flame flue. Gas coming from the gas producer to the boiler passes through a regulating valve, and thence onward to the combustion flue of the boiler, where it meets with a current of heated air, and, entering into combustion therewith, the flame circulates first through the combustion flue, as shown, afterward around the boiler at the sides, and finally underneath on its way to the chimney. The boiler is set in brickwork, in much the same manner as for firing with solid fuel, the chief difference consisting in the provision of a double series of channels underneath, through some of which, as indicated by arrows, the products of combustion pass away to the chimney, while the inflowing air to the boiler passes through adjoining channels. By this means the products of combustion leaving the boiler are deprived of most of their sensible heat, the action being so perfect that at a large works where these improved gas fired boilers are used exclusively, the temperature in the main chimney flue at a short distance from the boilers has been found to be much below the point of boiling water. As shown in the diagram, inside the combustion flue of the boiler are placed fire clay rings, the object of which is to prevent contact of the flame with the plates of the boiler. A ring at each end of the combustion flue will suffice in short boilers, but where the length of flame flue exceeds say 10 ft. or 12 ft., as is generally the case with boilers in this country, additional rings are provided at intervals. The flame flue should be clear from end to end, as cross tubes would interfere with proper combustion, and it is preferred to have boilers, such as Cornish boilers, with only one large flame flue, although at some works boilers with two flame flues are used.

The character and quality of the flame are subject to complete control by means of the gas regulating damper already referred to, the air regulating dampers, and the chimney damper also provided. By means of these dampers the temperature of the flame may be increased or diminished at will, or, in other words, the production of steam may be augmented or reduced at pleasure, and in either case without the production of smoke. In the papers which had been read, it was said that it was possible to avoid the production of smoke in boilers fired with solid fuel, provided that they are not pushed for the production of steam, which implies that the fires shall be kept thin and be supplied with an excess of air; otherwise smoke cannot be avoided. But in the case of boilers fired with gas and heated by radiation, no smoke need be produced under any conditions of working, that is, whether a large or small quantity of steam be required at any time; in fact, the presence of smoke would reduce the temperature of the flame and cause a diminution in the production of steam, so that the men in charge of such boilers would find it convenient, and to their own interest, to avoid the production of smoke. Where a range of boilers is fired by gas, it is preferable to place them under a foreman who understands how to regulate the production of steam by regulating the supply of combustible gases to the boilers, and who can keep the men attending to the gas producers up to their work. Under such conditions boilers at work give regularly an evaporative power of from 9 lb. to 10 lb. of water per pound of coal burnt in the gas producers. These results compare favorably with the best solid fuel fired boilers, but better results having been obtained, under certain circumstances, in later applications, it is confidently expected that an evaporative power of from 11 lb. to 12 lb. of water per pound of coal will be obtained as a constant result. Where small fuel is available, it can be used in the gas producers for the production of the gas required for firing boilers, and the saving thus effected, added to that in weight of fuel, will in many cases produce an economy of from 40 to 50 per cent. in the firing of boilers upon the present practice with solid fuel. This result will be obtained with less attention, or hard work, in firing, and will be attended with greater durability of boilers, and last, though not least, with total absence of smoke.

Messrs. Nettlefolds have adopted the Siemens gas fired boilers, to the exclusion of any other system, for their new works near Newport, Monmouthshire, and have eight such boilers, 28 ft. long by 7 ft. diam., in constant work, producing steam at a pressure of 70 lb. per square inch. This firm had arranged to build ten such boilers, if necessary, to produce the steam required for their works, as in the case of solid fuel boilers being adopted they would have required eight boilers with superheaters, and the cost of superheaters would have been the same as the cost of two additional boilers



GAS FIRED STEAM BOILERS.

Superheaters are, of course, inapplicable where the gases leave boilers at the low temperature mentioned; and it is satisfactory to find that the two aditional boilers proposed to be employed have been found to be unnecessary, so that the cost of these boilers themselves and settings has been saved. Sixty gas fired boilers have also been fitted with rings in the combustion flues at the Barrow Hematite Steel Company's works. This application was made after careful trial to one, and subsequently to six boilers, when it was found that the altered boilers gave distinctly greater evaporative power than the boilers not altered, although all boilers were supplied with the same quantity of gas from the same source; but that source being blast furnaces, the advantage of the application could not be ascertained in figures. Many applications of gas fired boilers have also been made on the Siemens radiation principle in Germany and Italy, with results as satisfactory as those given above. In Germany, where brown coal is used containing a large proportion of non-combustible substances, the figures quoted of course do not apply; but as compared with boilers fired with solid fuel of the same kind, the advantages realized are relatively quite as favorable.—*Industries.*

AN AUTOMATIC INTERMITTENT SIPHON.

As well known, the general solution of the problem of storing water, a vital question for agriculture, is the following: To unite all the sources that are not utilizable, on account of their too feeble discharge, in a reservoir of appropriate dimensions which is emptied one or more times in twenty-four hours through a sluice of dimensions such that the water collected can be entirely distributed over the surface to be irrigated, in a relatively short time. Experience, in fact, has proved that if water is profitable distributed to profusion, it is but slightly so when it flows in a thin stream in a trench of which it wets only the banks.

Instead of having a sluice to be opened at definite intervals, it long ago occurred to some persons to make use of the ordinary siphon. It suffices, in fact, that the latter shall prime itself automatically in order to have a rapid and intermittent emptying of the reservoir. But the conditions necessary for such automatic priming are sometimes difficult to carry out. The source, in fact, must be very regular, and have a pretty large discharge, larger than that of the siphon during the short space of time in which the latter, operating at first as a waste pipe, is upon the point of priming itself. If this critical point is passed, the priming is effected and the reservoir is emptied by reason of the greater velocity that the head of water gives the liquid in the siphon.

But if the source is intermittent, irregular, or diminishes, it may happen that the siphon will no longer perform the functions of anything but a waste pipe. Priming will no longer be able to be effected, and the abrupt emptying of the reservoir will no longer take place.

In certain special cases, this state of things can be remedied by establishing a well of water for the reception of the long branch of the siphon. The overflow is thus reduced and the priming can take place.

This, in reality, is merely a palliative of a result that is so uncertain in all cases that it is usually preferred to empty the reservoir by opening a sluice at stated intervals. Hence an annoying restraint, and a very poor utilization of the water at one's disposal.

In fact, the land owner, farmer, or metayer generally opens the sluice in the morning and evening. Between these two intervals and at night, if the reservoir is full, the water flows out slowly, and irrigates but a small surface.

Different means have been proposed for obtaining an automatic discharge, and especially for preventing the ever possible neglect to maneuver the sluice. At the last agricultural exhibition at Tulle, we had an opportunity of examining a recently devised and very simple system, the great advantage of which is the entire absence of any mechanism whatever subject to get out of order. It is a siphon, but it has been so arranged by Mr. Delavallade that the problem is entirely solved despite all the difficulties that we have enumerated. Its very regular operation is one of the most interesting things to study close by, as we have been able to do. Fig. 3 gives a general view of the apparatus and the manner in which it is arranged in the sluice hole of a reservoir. Thus placed, and supported by two wooden posts, one has no longer to pay any attention to it. Whatever be the irregularities in the discharge of the source, the siphon will never act as a waste pipe, and will prime itself as soon as the desired level of water is reached in the reservoir.

The latter once empty, the siphon will be unprimed, and will reprime itself a few hours later. The instant of unpriming, and consequently the level of the water remaining in the pond, is fully under the control of the farmer. It suffices, in fact, to form a series of apertures, *a*, in the short branch of the siphon and close them with wooden plugs that are removed according as it is desired that the water shall descend to such or such a level in the reservoir.

As shown in the sections in Figs. 1 and 2, the apparatus is constructed in two different forms, but the principle of both is absolutely the same.

The bell siphon (Fig. 1) consists of a tube, which is inserted in the sluice hole and is provided at its upper part with a circular water reservoir (A). A movable bell, provided with an internal circular diaphragm (B), covers the whole and rests upon the tube. It is provided with two small external reservoirs (R R') connected by a tube (*t*). The lower reservoir, R', communicates with the interior of the bell, through small apertures.

Two bent tubes, T T', put the reservoir, R, in communication with the two chambers, $\alpha\beta$, formed in the bell by the diaphragm, B. A third tube, S, below the two others, starts from the reservoir, R, traverses the bell, and hangs vertically in the interior of the central tube fixed in the sluice.

Fig. 2 represents the second form of the apparatus. It is an ordinary doubly revolving siphon. The general arrangements are the same as those that we have just described. It is to be remarked that the part, A, of the bent siphon will always remain full of water, like the reservoir, A, in the bell siphon.

Let us suppose that the pond has just been emptied; the unprimed siphon will be entirely empty, except in the parts, A. The water gradually rises in the reservoir, and consequently in the short branch of the siphon, in the reservoir, R, through the intermedium of the reservoir, R', and in the three tubes, T, T', S. In measure as the water rises, the air is driven forward until the moment that the siphon is about to operate as a waste pipe. It thus takes a certain pressure in the chamber, α (tube, T), on account of the presence of water in the internal reservoir, A. In the chamber, β, on the contrary, it remains at the pressure of the atmosphere, since the long branch of the siphon

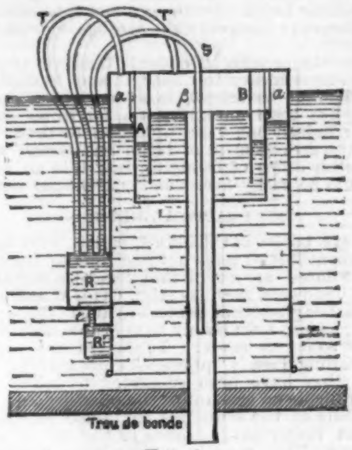


FIG. 1.

opens in the free air. It is starting from this moment that the automatic priming of an ordinary siphon may take place, if the requisite conditions of discharge be present, the air confined in the upper parts being carried along by the first jet of the liquid. If such conditions are not fulfilled, there always remains in the upper part of the siphon or of the bell some air that must be got rid of, or the pressure of which it will suffice to diminish sufficiently to produce

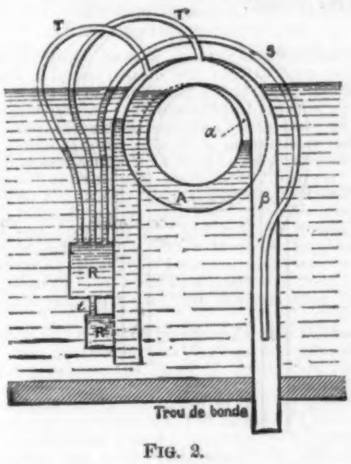


FIG. 2.

an abrupt ascending motion of the internal liquid column, and consequently a priming.

Such is the principle to be applied, and the way it is done is as follows. In consequence of the presence of a certain volume of compressed air in the internal chamber, α, the velocity of the siphon's flow as a waste pipe is infinitely small, and increases proportionally much more slowly than under ordinary circumstances with the external level of the liquid. It results from

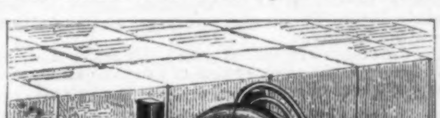


FIG. 3.—INTERMITTENT SIPHON.

this, that whatever be the discharge of the source, the tube, S, placed beneath T and T', will be very quickly immersed.

In reality, this tube is merely an auxiliary siphon whose diameter is small enough to allow its priming to be always certain. It will therefore empty the reservoir, R, almost instantaneously. As, on another hand, the latter can fill itself but slowly, on account of the small diameter of the tube, *t*, there will occur, in order to fill the vacuum formed, an abrupt draught and a putting in equilibrium (through the tubes, T and T') of the air occupying the internal chambers, α and β. At this very moment, the jet of water issuing from the auxiliary siphon in the central tube, or the long branch of the siphon, causes a suction in the chamber, β, and establishes in the whole (α β) a pressure sensibly less than that of the atmosphere. From this complete rupture of equilibrium between the internal liquid and gaseous strata of the siphon results a sort of ram stroke that effects an automatic priming. From the very beginning, the remaining air is carried along by the liquid, with a considerable velocity, dependent upon the height of the water in the pond, which latter rapidly empties until the apparatus is unprimed.

The system, with a few slight modifications of detail, is applicable as follows: 1, to the flushing chambers in the sewers of large cities; 2, to the submersion of meadows, and in general to all the problems of irrigation; 3, to the automatic emptying and renewing of the water in garden fountains and in ponds especially set apart for pisciculture; 4, and, finally, to the draining of quarries, mine holes, etc., without machines, provided there be a low point for the flow.—*La Nature.*

CAREY LEA'S PHOTOCHLORIDE OF SILVER.*

By WILLIAM LANG, JR.

THE alchemists of old had their philosopher's stone and elixir of life, and many, indeed, were the attempts made by those early pioneers of chemical science to wrest from nature what they considered would be of untold benefit to mankind. I take it, gentlemen, that if anything in our art is or can be considered as analogous to the philosopher's stone of the alchemist, we will find it in that branch of photography which has received the name of heliochromy. Photography in natural colors would indeed be a grand achievement, but the question is, Are we any nearer its accomplishment than we were in 1848, when Becquerel laid before the French Academy of Science his silver plate imprinted with the colors of the spectrum? I think, gentlemen, the position of affairs at the moment is this: If silver chloride is to be the medium by which a transcript of the colors as we see them in nature is to be arrived at, we should very soon now be able to say definitely whether the thing be a possibility or not. As you are aware, there have been many workers in this field. It will be sufficient to recall to you the names of Niepce de St. Victor and of Poitevin, of Herschel, Hunt, and Abney. Becquerel's work we have already alluded to. One would have thought that by this time all the changes that were possible had been rung, as far as production of color from silver chloride was concerned, but that such is not the case is remarkably evident from the contribution to photographic science that has lately been made by Carey Lea. In the May, 1887, number of the *Amer. Journal of Science*, the first of a series of papers made its appearance, having for its title, "On Red and Purple Chloride, Bromide, and Iodide of Silver—on Heliochromy, and on the Latent Photographic Image," and it is some of the facts brought forward by the American experimentalist, not only in the May, but also in the June number of the *American Journal of Science*, that we purpose laying before the members of the convention this evening. Carey Lea's memoirs are so full of suggestive material, that in a communication such as the present, one or two points only can be touched upon. Those interested in the chemistry of photography will recognize at once the importance of the researches that have been carried out. The whole contribution is remarkable for its originality, and it takes its place at once in the first rank of the many classical researches which from time to time have enriched photographic science. Carey Lea's views regarding the latent image may, or may not, be ultimately accepted by those competent to form an opinion; but the fact remains that his experiments will form the starting point for further investigations. It is no small matter for the experimentalist to be able to produce in the laboratory, and in quantity, that colored form of silver chloride which hitherto has only been obtained, and that in what might be termed infinitesimal quantity, on the surface of silver chloride by the agency of light. To the colored substance thus produced, Carey Lea has given the name of photochloride, and specimens I beg herewith to put forward for your inspection. It is worthy of notice that this photochloride can be obtained by a great number of methods. For these we must refer those interested to the original paper. It will be sufficient for the present to indicate that particular process by which the specimens now before you have been obtained. Freshly precipitated silver chloride, after washing, was dissolved in ammonia, and to this a solution of ferrous sulphate was added, producing an intensely black precipitate. Dilute sulphuric was afterward added till a slightly acid reaction was manifest. Thereafter the precipitate was well washed by decantation, and boiled with dilute nitric acid; washing was again resorted to, and the product treated with hydrochloric acid dilute, boiled, and finally washed. I show specimens of the substance both in the moist and dry state. I have also prepared the corresponding photo-salts obtained from the bromide and iodide of silver, thinking that they would not be without interest, and here are the specimens of photoiodide and photobromide in question. Their mode of preparation is somewhat similar to the method employed in the case of photochloride, but here, again, we must refer members for particulars to the original communication reproduced in our own two leading photographic journals.

To come back to the consideration of the photochloride, the question naturally arises, What is it? Its discoverer describes it as a combination of silver chloride with its own subsalt; but one extraordinary thing connected with it is that no two specimens, although to all intents and purposes prepared in the same way, show the same percentage of subchloride to that of the normal chloride. The amount of the former substance, combined with the latter, seems to vary from half per cent. to something like nine per cent. To quote Carey Lea's own words: "Even when silver chloride, bromide, or iodide contains as little as one-half of one per cent. of subsalt combined, its properties are greatly changed. It has a strong coloration, and its behavior to light is

* A communication to the Photographic Convention.

altered. Even a much less quantity, one inappreciable to analysis, is capable of affecting both the color and the behavior to light.

It seems to me that much experimental work will have to be done before a clew to these variations will be satisfactorily obtained. To enumerate all the reactions of this phenomenal compound would simply weary you; one striking characteristic may perhaps be alluded to, and that is its being able to resist for a considerably lengthened period the action of boiling aqua regia. Referring to the colors assumed by this Protean substance, Carey Lea specifies that it "shows all the warm shades from black to white through the following gradations: white, pale flesh color, pale pink, rose color, copper color, red purple, dark chocolate, black."

Another point will require elucidation before the complete identity of the chloride, colored by the agency of light, and the photochloride produced in the laboratory, be established, and that is, is oxygen present in the latter substance? Carey Lea says nothing in his memoir that would indicate the presence of oxygen. Dr. Hodgkinson's experiments demonstrate what other experimentalists previously had inferred, that in colored chloride produced by light, oxygen is invariably present. I feel sure we will not have long to wait before an answer will be given to the question here raised.

I think it would be doing Carey Lea great injustice were I not to allude to a discovery he has made, and which is embodied in his memoir, viz., that he is able so to affect a film containing a silver haloid by application of a chemical reagent, that he can produce a result equivalent to the latent image formed by the agency of light. The body which gives this result in the most pronounced manner is sodium hypophosphite. It virtually, according to Carey Lea, converts the haloid into a photo. compound, producing no visible change; but when a developing agent is applied, the action is rendered manifest.

At the conclusion of the article which appeared in the May number of the American journal already referred to, we find Carey Lea making use of the following language: "I am persuaded that in the reactions which have been here described lies the future of heliochromy, and that in some form or other this beautiful red chloride is destined to lead eventually to the reproduction of natural colors." Now, gentlemen, does this language seem too extravagant? For my own part, I do not think so. The impossibilities of one age become the veriest possibilities of the next. I do not think that even were we able to depict the colors of nature on the photographic tablet, that accomplishment would transcend in value the fact that we are able now, in the merest fraction of a second, to record the most rapidly moving object that can be presented to our cameras. At the commencement of my paper I drew, as it were, a parallel between the alchemist of the past and the photographer of the present. Permit me to continue it; and should it ultimately be found that a research such as Carey Lea's does not lead up to the philosopher's stone of the photographer, does not render possible the reproduction of the colors of nature, still the work he has done will be of lasting value to those interested in the chemistry of the silver haloids. Brewster, many years ago, in his letters on "Natural Magic," wrote as follows, and I think that what he then said regarding alchemy will show that what after all may turn out to be a dream is not without its beneficial result: "Though the philosopher's stone has not been found, chemistry has derived rich accessions from its search; though the general solvent has not been obtained, yet the diamond and the gems have surrendered to science their adamantine strength; and though the elixir of life has never been distilled, yet other substances have soothed 'the ills that flesh is heir to,' and prolonged in no slight degree the average term of our existence."—*Photo. News.*

METHODS OF TEACHING AND LEARNING MODERN LANGUAGES.

By Professor CHARLES F. KROEH, of the Stevens Institute of Technology.

THE purpose of the present article is to describe various methods of teaching and learning modern languages. The writer has had ample opportunities for testing these methods during the last twenty years by actual experiment in the class room, and therefore speaks from experience.

An examination of methods will be useful, because modern languages are studied by children and adults for a variety of purposes, as for example:

1. As an accomplishment.
2. Because other schools offer them, and with no special ulterior object, or with a vague idea of some intellectual benefit.
3. To serve the purpose of a summer trip abroad.
4. As a means of improvement in the use of the vernacular.
5. For general culture obtainable by reading foreign literature.
6. For philological research or amusement.
7. For acquiring the ability to consult foreign scientific and technical publications.
8. For business correspondence.
9. Because business, family or friendly relations bring with them personal intercourse with foreigners.
10. To teach them to others.

It is evident at once, then, that no one method can be the best in all cases.

The great multitude of instruction books upon our shelves may be reduced to very few general modes of procedure that deserve the name of systems or methods.

THE SCHOLASTIC METHOD.

When Latin ceased to be a living tongue, some schoolmaster, whose name has not come down to us, conceived the unlucky idea that the proper way to learn Latin was by studying those excellent books of reference, the grammar and the dictionary. In proportion as boys learned less and less Latin, more and more importance was attached to the study of grammar. Parents of an inquiring turn of mind, who wished to know the reason why their sons could not read Latin very fluently after four to six years of instruction, were consoled or silenced with the plea that the boys were receiving valuable mental discipline!

The same method naturally came to be applied to modern tongues; for it required a minimum of talent and exertion on the part of the teacher. In due time, clear-headed men protested against such a process. Among others, Locke in England and D'Alembert in France proposed a different way. Says Locke, for example: If you cannot get a man to talk Latin to your children, the next best thing is by taking some easy and pleasant book, such as Æsop's Fables, and writing the English translation made as literal as can be in one line, and the Latin words which answer to each of them just over it, in another. These let the children read every day, over and over again, till they perfectly understand the Latin. Of the grammar, he recommended beginners to learn only the conjugations and declensions.

In accordance with this plan, Hamilton prepared a series of interlinears to Cæsar, Cicero, Xenophon, etc. When I went to school, however, it was considered nothing less than moral degradation to use such aids. There is indeed one valid objection to their use, and that is the arrangement of Latin and Greek words in the English order of thought; but it is an objection that could be easily overcome by a skillful teacher.

THE PRACTICAL METHOD.

The text books of Ollendorff, which were first published about 1846—I have not had time to hunt up the accurate dates—are a type that has been imitated by a host of followers, such as Ahn, Otto, Woodbury, etc. They embody another protest against the scholastic method, which, I am happy to say, now rests in peace, at least so far as modern languages are concerned. Their leading idea is "practice before theory," and although they have been subjected to much well deserved ridicule on account of the puerility and absurdity of some of the sentences contained in them, they mark an important advance in the art of teaching languages. They contain a very large vocabulary of common words and phrases with their translation, and two kinds of exercises, one to be turned into English and the other into the foreign language. No grammatical aid is given except what may be gathered from an appendix and a few foot notes. This reaction against grammar was evidently too great. Sound instruction in language cannot be divorced entirely from grammar. The inflections, agreement, government and collocation of words must always form the basis of instruction. Technicalities can be dispensed with, and there is no use in teaching formally what the pupil can be led to find out for himself.

THE ROBERTSONIAN SYSTEM.

The Robertsonian system, named after Professor T. Robertson, who taught for many years in Paris, appeared about 1852. It is a modification of the interlinear plan, with notable improvements. A continuous story is given in forty short sections, each accompanied by an interlinear translation and also an idiomatic version. The teacher is directed to read the first lesson five or six times to the pupil, who then familiarizes himself with the spelling and the meaning of the words until he can write them correctly from dictation and from memory.

Each lesson of this kind is followed by a set of questions and answers made up of the words and phrases already learned, and by a series of sentences to be translated first from and then into French. These sentences also contain nothing that has not been explained.

The learner may then go on through the book in this way, skipping the second or theoretical part of each lesson and come back to it on the review, or he may take it at once.

Now and then lists of words are given that are easily remembered by reason of their similarity to English.

The whole is followed by twenty lessons more, in parallel columns, for translation from and into French, and by a short synopsis of grammar.

This system is represented in Germany by what is called the *Toussaint-Langenscheidt Method*, which appeared in Berlin, about 1860, in the form of thirty-six letters, each containing two lessons. The basis of the French is Chateaubriand's Atala, and of the English Dickens' Christmas Carol. Each section is accompanied not only by two translations, but also by the pronunciation denoted in a most excellent manner. Besides the features of Robertson's book, conversations on practical subjects, correction of Germanisms, forms of letter writing, lists of idioms and war terms and an outline of literature are given.

Dr. Carl Sach's Encyc. Wörterb. der franz. u. d. Spr. is based upon the same system of pronunciation, and is one of the best bilingual dictionaries in existence.

GAILLARD'S MODERN FRENCH METHOD.

Prof. J. D. Gaillard, now of New York City, has published a method which possesses considerable originality. Like Robertson, he uses a continuous story as a basis; but unlike him, he first teaches his pupils pronunciation and the elementary principles of grammar, including the verb. Then he gives them a section of his story without the connecting words; thus: S'appeler—George d'Estainville—issu—famille—Huguenots—exilés—au temps—persécution—Protestants—Louis Quatorze. These words are printed in one column, with the translation opposite. The teacher supplies the intermediate words, making a connected narrative, which the pupils repeat after him, first without sight of the book and then with the text before their eyes. They next prepare this lesson at home, by committing the different connected groups to memory, so that they can speak and write them. When they come to class again, a dialogue of the following nature ensues between teacher and pupil:

T—Notre héros
P—s'appelait George d'Estainville.
T—Il était
P—issu
T—de l'une de ces nombreuses et honorables
P—familles de Huguenots exilées au temps de la persécution
T—de la persécution
P—des Protestants
T—sous le règne du roi
P—du roi Louis Quatorze.

The next step is conversation by question and answer. For this purpose a series of questions is given with interlinear translation, and to these the pupils reply, by using the material just acquired. Conversation is also practiced between pupils, one asking and another answering. After some time they are required to give a continuous narration of portions of the story, and also to write them out from memory. After the twentieth lesson, a mere sketch of suggestive words is given, which are to be worked freely into a narrative.

The features upon which most stress is laid are that the words and phrases of the fundamental story are grouped according to the law of the association of ideas, and that the subjects treated impart knowledge and excite interest by appealing to human feelings. It is claimed very justly that these features are of great service in helping the learner to remember.

It remains to be added that the interlinear translation is idiomatic, and does not give the meaning word for word, and that many of the subjects discussed require a somewhat matured intellect.

Too much must not be expected from the claim that the law of association has been followed. In our own language, where we have to deal with familiar words, this law applies, and we can remember a series of words connected in sense, like: Fire! bells, excited crowd, flames, distracted mother, brave fireman, ladder, rescued child; better than a series of disconnected ones, like: Barrel, sky, to waltz, rooster, windy day, murder, apples, volcanic eruption. But in a foreign language, where the words are still unfamiliar, the law of association is of little assistance at first.

MARCEL'S RATIONAL METHOD.

Claude Marcel (about 1868) considers the ability to *understand* spoken language and to read of more importance than speaking and writing. He would have us begin the study of a language by reading at once without any previous preparation. His arguments and directions are as follows.

To prevent mistakes, do not pronounce the foreign language at all, either aloud or mentally, but let the information enter through the eye alone. Pronounce instead the English equivalent of the passages under consideration. The book should be very easy, and should contain a close English translation on the opposite page. The learner compares the two pages, sentence by sentence, and infers the meaning of as many words as he can. The use of grammar and dictionary is forbidden. To use the latter would be to substitute the thumb and finger for the intellect.

Read in this way five or six volumes two or three times over in three months. At first all is confusion, but light will gradually dawn; because the most useful words occur the most frequently. On seeing them in different positions, we receive successive additions to our first impression, and thus our knowledge of their meaning is gradually built up. By continuing to read, we become more and more independent of the translation, and finally discard it altogether.

The art of reading in this way can be acquired without a teacher. The next step consists in training the ear to the art of understanding the spoken language. The teacher now reads aloud what his pupils have translated, while they follow him without looking at the text, and translate by ear. At first he reads slowly and by phrases, and then gradually faster and more connectedly. After some time, they will understand him when he reads what they have not prepared beforehand, and when he speaks so rapidly that they have no time to translate. The art of speaking, adds Marcel, will then follow as a necessary consequence.

Marcel considers narration better than conversation, and asks: "What conversation can there be between a master and his pupils?" Accordingly he recommends relating anecdotes, historical facts, and noteworthy events. His remarks are intended principally for the study of French, which he thinks a pupil of suitable age should be able to read with pleasure and speak with ease in eighteen months or two years.

It will occur at once to an experienced teacher that his pupils will generally violate Marcel's directions as regards pronunciation. They will pronounce mentally according to the analogy of English, and thus render it more difficult for themselves to acquire the correct sounds afterward.

Again, the spoken language corresponds so little to its conventional representation on paper, that the pupil's previous silent reading will be of little service to him when he comes to hear the same text read by the teacher. As the time must come sooner or later when the sounds are associated with letters, syllables, words, and phrases, it is difficult to see the advantage of postponing. Besides, if the sounds were taught first, they would assist in remembering words. The combined memories of the eye and the ear are manifestly better than either alone.

The excellences of Marcel's method are his substitution of the intellectual processes of comparison and reflection for the use of grammar and dictionary, and his recognition of the importance of the conjunctions, prepositions, pronouns, and short adverbs which constantly recur on every page. There are hardly 300 of them, and yet they are used more than all the remaining 100,000 words of the dictionary.

For languages like Greek, Latin and German, in which the collocation of words differs widely from English, an interlinear translation would be necessary to carry out Marcel's ideas; but the words of these languages should not be taken out of their natural order and arranged after the English sequence, as is done in the interlinears of Hamilton. Students should be led to understand them as they stand, viz., to take in the full meaning of each word or phrase as it comes without mentally rearranging. My "First German Reader" and "Die Anna-Lise" are arranged on this plan for German. In French a number of books have been published besides Marcel's own. Among them may be mentioned Mme. Barbauld's Lessons for Children; French Children at Home; Comment on Parle à Paris; Le Voyage à Paris, by Williams; Collot's Interlinear French Reader; and Roemer's Polyglot Readers, which contain the same pieces in English, French, German, Italian, and Spanish. Books of this character are of especial value to those who study without a teacher.

My experience does not incline me to agree with the idea that reading leads directly to speaking. If any one desires to discover why reading usually contributes so little to this end, let him ask a student to repeat from memory some simple idiomatic sentence of very moderate length that he has just read. The student will rarely be able to do so; because, in fact, he has not performed any mental operation analogous to speaking. He may have perfectly understood the sense of the

passage, but he has not transferred the words to his mind, nor treasured them in his memory, nor combined them with those already there.

THE MASTERY SYSTEM.

Thomas Prendergast, an English writer of decided originality, found, about 1867, that lads who had been carefully drilled for three or four years in translating English into French and German, grammatically, were incapable of putting ten words together idiomatically until they went abroad and learned by imitation; also that in the examinations one who could speak idiomatically was rated below those who had a thorough knowledge of grammar, but could not speak.

Children, he says, instinctively imitate and repeat chance combinations of unfamiliar sounds; only after some weeks they begin to speak a few sentences which they multiply by transferring words and phrases from one to another. The mastery system substitutes skillfully constructed sentences for these chance combinations, but conforms otherwise to the procedure of children.

There are 200 or 300 common words in every language, some of which necessarily occur in every sentence. The profusion of speech which we observe in children springs from their power of wielding these 200 or 300 words with a gradually increasing stock of nouns and verbs interspersed. To these words the learner should therefore devote himself at once. They should be arranged for him in a sufficient number of lengthy and complicated sentences to illustrate all the constructions in use. Each sentence, moreover, should be accompanied by a number of variations, in which the same words are recombined to form new idiomatic sentences.

Now for the manner of studying. Suppose, for example, that the first sentence is:

"Unless we send word to the hotel immediately, we shall have no chance of obtaining horses, because there is a great demand for them." (Prenderg. Spanish.)

From this sentence about 25 variations of different lengths would be given in which no other words are used. The fundamental sentence is translated word for word, and the variations are accompanied by a free translation on the opposite page.

Each of these sentences must be learned in the most perfect manner, until they can be spoken with the utmost fluency, accuracy, and promptitude. If a mistake is permitted in a single word, or even in a single sound, the system is virtually abandoned.

To insure this accuracy, the learner is advised to learn very short lessons, never to continue more than ten minutes at a time, and to make from three to six such efforts every day. The most common error is to furnish the beginner with more material than he can retain. Perfect retention must be aimed at, and the power of retention is much smaller than is generally supposed. The mastery of ten new words daily is far beyond the power of a person of average capacity and industry. Those who doubt this statement are invited to try the experiment fairly for thirty days.

The beginner is not allowed to compose any sentences for himself. He is merely the recipient of a stock of practical sentences, which in due time become models for other sentences.

The reason for beginning with complicated sentences is that children do not discriminate between what we call simple and difficult constructions, but employ the latter as readily as the former. So the learner must not disdain to commit them to memory and to reserve the solution of difficulties for future experience.

During the first fortnight the beginner is not allowed to trust his memory. In order that mistakes may be avoided, he must rehearse with his teacher before reciting, and the teacher must prompt him at the slightest hesitation.

When the first sentence and its variations are perfectly mastered, the second is taken up, and the variations then contain the words of both.

When two hundred words have been mastered in this way, the learner is permitted to use a table of terminations of the variable parts of speech, and to vary the sentences by changing the parts of verbs, the case and number of nouns and pronouns, etc. He may also exchange congruous words, as *before* for *after*, *came* for *went*, *his* for *her*, *to-day* for *yesterday*. From two sentences of 10 congruous words each, we can thus make 1,024 variations, and from three, 59,049. The thorough mastery of a few gives the command of all.

During this course no reading must be done and no grammar or dictionary used.

It will be seen that the acquisition of colloquial fluency is here considered as a purely mechanical process, dependent upon the memory and not the intellect, and that composition is regarded as putting together idiomatic phrases by an intelligent effort of the memory, and not as compounding sentences according to the prescriptions of the grammarian.

The great merit of Prendergast, whose system has just been described, largely by condensing his own phraseology, consists in formulating so exactly the problem to be solved in learning to speak a language. His solution of the problem, however, is one that involves mere drudgery unrelieved by any interesting exercise.

THE MEISTERSCHAFT SYSTEM.

The so-called Meisterschaft system, by Dr. Richard S. Rosenthal, is copied directly from Prendergast's mastery system, of which its title is a translation. The author claims that he has greatly improved upon the original by confining himself strictly to the necessary phraseology of everyday life, and adding only so much grammar as must be known for all practical purposes. This claim is well founded so far as some of his model sentences are concerned, for they are certainly more useful than those given by Prendergast, while others have been but slightly altered. His directions for pronunciation (of French, for example) are simply abominable, and his means of imparting the vocabulary of 2,000 to 2,500 words which he considers necessary is by giving them in long lists.

COLLAR'S EYSENBACH'S GERMAN LESSONS,

which I have just received, seems to be an attempt to graft the Prendergast idea of beginning with sentences and their variations upon a grammatical course. It has the appearance of a very useful book.

THE NATURAL METHOD.

Although there have been teachers probably ever since the time of Pestalozzi, and perhaps before, who availed themselves of object lessons to some extent in teaching languages, the merit of originating the so-called natural method is due to Gottlieb Heness in the same sense that the discovery of America is due to Columbus rather than to the Norsemen.

In 1865, while Heness was explaining to a friend the advantages of object teaching, as used in Southern Germany, to help children in overcoming their dialects, the thought occurred to him that this means might be made of service in teaching German or any other language. About six months afterward, he promised to teach the sons of several Yale College professors to speak German fluently in one school year of 40 weeks, 5 days per week and 4 hours per day. In this undertaking he was so successful that he opened a school, taught his method to Dr. L. Sauveur, and engaged him to assist in French. The method has since become widely known, especially through Dr. Sauveur's publications and summer schools.

The method consists in speaking only the foreign language in the class room, as though English were not in existence. The teacher begins with short sentences about some object in sight in such a way that the pupils cannot fail to understand him. He holds out a book, for example, and says: "Here is a book;" a pencil, and says: "Here is a pencil." Then, perhaps, he puts the pencil in the book, and says: "The pencil is in the book." Thus he continues by going through ordinary motions of every day life, suiting the action to the word. By judicious questioning, the pupils are led to reproduce the phraseology they have heard. It is like living in a foreign country under favorable conditions.

Taking care to introduce but one new word or phrase at a time, the teacher continually combines in new ways the words already acquired by the pupils, and soon reaches a point at which it is rarely necessary for him to have recourse to pantomime or even to visible objects.

His next step is to lead up to some easy reading by preparing his pupils beforehand for the new things and the difficulties to be encountered. His object in doing so is to enable them to read the piece as a native does, without the necessity of translating. When they have read the piece, he drills them conversationally on the phraseology until he has reason to believe that they have transferred it to their working vocabulary. Perhaps he finishes by making them learn the piece by heart.

Grammar is taught in installments as soon as it can be understood when explained in the new language; in my own practice, about the tenth or fifteenth lesson. Translation is postponed as long as possible.

When the learner's vocabulary is sufficiently extensive, he is required to relate anecdotes, to condense stories he has read, to convert poetry into prose, etc. At this stage, it is claimed, he will enjoy all the beauties of literature exactly as a native does. There is now no further objection to his translating from one language into the other for the purpose of improving his style in both and of acquiring that nicety of discrimination which we admire in scholarly writers.

Let us now examine the objections which have been made to this system.

It cannot be denied, we are told, that the most natural process for learning a language is that through which little children pass. They listen to their mothers and companions, watch their facial expressions, their gestures and actions, and then imitate both the action and the accompanying words. But, in this way, about ten or twelve years are consumed in acquiring a commonplace, colloquial vocabulary. To this the child adds constantly with its increasing experience derived from intercourse, reading, and study. The acquisition of knowledge goes hand in hand with the acquisition of terms to express it, and the process never stops.

Now, when a young man enters college at the average age of 18, it is manifestly too late to repeat this lengthy and wasteful process with any other language. Besides, the conditions will never again be the same as those under which he learnt his mother tongue. His own mental organism has changed. He has lost much of the spontaneous receptivity and plasticity of mind peculiar to childhood, and has developed in exchange the faculties of comparison, reasoning, and generalization.

He is now, moreover, already in possession of the means for expressing his thoughts. The words of his vernacular have become thoroughly connected with the ideas they represent, and have linked themselves to form a vast number of inseparable chains of phraseology. A new language must displace all this. His mind now runs in deeply worn grooves. Consequently, the new language has not the same chance of success as the first. It has a habit to overcome. The older the student, the more firmly established the habit and the more extensive the vocabulary to be displaced. An adult will not be content with the commonplaces of children. Hence he must work all the harder to attain fluency.

Reasoning similar to that which has just been given has led some writers who are imperfectly acquainted with the capabilities of the natural method to decide that it might be suitable for children, but not for adults. As in so many controversies, the difficulty here is in a name. The natural method is not the process by which children learn from their mothers. It is, or ought to be, a great deal better than that, though based upon it. It is natural in its basis, but highly artificial in its development, and hence the name by which it has become known is, to a certain extent, a misnomer. But we cannot change that now. We can only point out that the arguments just formulated do not apply to the natural method as it is, but only as it is supposed to be.

It has been objected that the teacher is required to do a disproportionate share of the work; that he must labor excessively to supply the place of dictionary, grammar, and foreign surroundings to his pupils; and that his memory must be under a continual strain to retain the exact vocabulary of all his different classes at every stage of their progress. A skillful teacher will, however, find means of lightening his labor and overcoming these difficulties.

Another objection that has been made is that the conversation necessarily turns upon trivial subjects, but my own experience has convinced me that this is true only at the outset; and since many of my adult pupils even find great difficulty in these very commonplaces, I must conclude that they are a necessary evil. Fortunately it is only a brief one.

It must not be supposed that the teacher is required by the natural method to lower himself in any way in order to amuse his listeners by converting his illustrations into a farce. He must possess a thorough command of his language; he must combine and recombine the vocabulary of his class skillfully and ingeniously, so as always to be understood; and he must have at his beck and call a wealth of illustrations, such as proverbs, winged words, anecdote and poetry, that will not permit the attention of his hearers to flag for an instant. He wields over them the power of an orator, and he may use it for their highest mental and moral good.

Again, it has been objected that this method fails to bring into play the higher faculties of the mind, and that it is folly to reject any philosophical aids to the study of languages, such as grammar and bilingual dictionaries.

The first portion of this objection will never be made by any one who has successfully used the method, even to a very limited extent. Such a teacher knows that his pupils are vigorously comparing and reasoning all the time, and he leads them to make their own generalizations as soon as they can do it in the language taught.

I cannot conceive of any philosophical aid to the study of languages that the "Sprechlehrer" cannot avail himself of. He certainly can and does teach grammar as thoroughly as it can be done by the old way.

It would be inconsistent to permit beginners to use a bilingual dictionary, for several reasons. It promotes mental inertia, because it is easier to look up a word than to reason out its meaning from the context; it is misleading, because it makes the learner believe that words exactly coincide in two languages, whereas they may only touch each other at one or two points, and then each may have its own distinct figurative ramifications, which are all natural enough, provided we do not mix them; and lastly, the very existence of English must be ignored during these lessons, for reasons which will presently appear.

Yet, notwithstanding all these reasons, it would sometimes seem as though we had rejected a valuable aid by dispensing with a bilingual dictionary, especially when we consider that beginners have no other means of pursuing their studies out of the class room. They cannot, of course, use a unilingual one until they have made considerable progress. But perhaps they had better not pursue their studies out of the class room at that stage. There is room for a difference of opinion on this point.

The advantage of the natural method over that which is based upon reading is obvious. It is hardly possible to hear a recitation of more than six moderate octavo pages in one hour, if nothing else is done than "hear the lesson." If there are explanations and comments, the lessons must be shorter. Now, it is not difficult to calculate that the conversation heard by the students in one lively lesson by this method would fill at least forty pages, as a fluent speaker uses about 250 words per minute, and a medium sized octavo page contains about 300 words.

The basis of all language, whether literary or scientific, is the phraseology of every-day life, and this can be learned only by imitation. In actual conversation there is no time to reason about the arrangement, agreement, and government of words or to translate them from one language into another. We must think directly in the language we are speaking. Now, I am not acquainted with any other system than the natural method that has provided the means of doing so. Its great merit, in my opinion, consists in the fact that it leads the learner *to associate the new vocabulary directly with objects and actions instead of their English names.*

The natural tendency of the learner is to translate the foreign phrases he hears and sees; but by this method he is soon convinced that he is wasting his time and only practicing English by so doing; because he can raise his hand, for example, and say, "I raise my hand," in any language without the necessity of first thinking it in English. By means of these preliminary object lessons, the habit of direct association is soon formed, and this I consider their chief value. Moreover, the student, on seeing before his eyes actions and objects and hearing them described, must receive more vivid impressions, and is therefore more likely to remember than where mere words are associated together, as in translation.

After a foreign language has been studied for a while as a living tongue, that is to say, after a limited number of words and phrases learned as described have become grouped and linked together in a great variety of ways and thoroughly incorporated with our brain fiber, reading will increase our command of the new language, just as it does in English, and for the same physiological reason. Nothing is then so absolutely novel and strange as not to find something kindred in the brain to which it can attach itself according to the laws which govern the action of the memory.

The proper time for systematically comparing two languages is when the student possesses a moderately good knowledge of both. I do not mean that all comparison should be postponed until then; only that such comparison should not be made the basis of instruction. The student will unavoidably institute some for himself; but he will never know a language as a native does unless he has learned to utilize its power of explaining itself.

From these considerations I conclude that the natural method furnishes the most philosophical introduction to the study of languages which has ever been proposed for the class room. For study without a teacher, where reading is the sole object, the interlinear system is recommended for languages differing widely in construction from our own, and the Marcel system for those which do not.

The natural method is, of course, interminable. Probably no teacher can pursue it to the point at which his pupils are able to express themselves in the new tongue as perfectly on all subjects within their range as they can in the vernacular. In my own course, I can go no further than to lay the foundation which has been so well formulated by Prendergast. Then we must read as much as possible and push forward to the ultimate object of our course—the easy comprehension of scientific and technological literature.

The greatest difficulty I have to encounter is the imperfect training or total absence of training of the ear in our schools. The education of our young people is

conducted almost exclusively through the eye by means of books. There is so little oral instruction that the pupils not only do not hear accurately, but have to learn the art of paying attention. To meet this difficulty, I have prepared drill books on the pronunciation of German and French, in which the difficulties are overcome one by one by systematic practice. By placing these books in the hands of students, I find, when I begin conversation, that my labor is very much lightened.

SELF-INSTRUCTION AND THE CLASS ROOM.

Permit me in conclusion to describe how I should avail myself of various aids in acquiring a language myself. I should undoubtedly begin by taking a course of lessons by the natural method until I was sure that my pronunciation was accurate and until I had mastered all the constructions. Then I should read a short grammar, written in the language I was studying, and thoroughly drill myself on declensions and conjugations, especially the irregular ones, rejecting, of course, all that are likely to occur but rarely.

The next step would be to read several thousand pages without consulting a dictionary, or at least without consulting it very often. This first reading must not be too difficult. It should consist of popular tales and even nursery rhymes and songs—everything in fact that a native learns first in his own language.

All the literature of a nation is full of allusions to these outgrowths of popular life, and many of them have enough intrinsic value to repay the trouble of storing them in the memory.

Then I should ascertain what are the best contemporary novels and plays, and read all the works of one good author first, because a man necessarily has a limited vocabulary and is obliged to repeat himself. I should select a writer of the realistic school whose realism confined itself to minute descriptions of the ordinary events of life; for my object would now be to surround myself artificially with the advantages which can be derived otherwise only from a residence among the people whose language I desire to master.

In all this reading, my constant endeavor is to avoid translating.

Whenever I reach a good colloquial sentence likely to be of service to me, because it contains either phraseology that must be used in daily intercourse or connectives, constructions, or idioms peculiar to the language, I impress it upon my memory, by repeating it once or twice without looking at the book and as though I were actually speaking to some one. Then I mark the sentence; and on finishing the volume, I renew my acquaintance with the marked passages by copying them in a note book.

It is astonishing how naturally the material thus stored in the mind becomes available for the purposes of actual conversation. Not the identical sentences, but their peculiar turns, come up as occasion arises to apply them.

If no such occasion arises, we must create one artificially, or else all our labor is in vain. We must think in the new language daily; that is, we must hold mental conversations with ourselves about familiar objects, scenes, and persons, and about our occupations; we must recall anecdotes and stories we have read; in short, we must entertain ourselves as best we can in the foreign language during our walks, rides, and moments of leisure and solitude.

While we can do all this for ourselves, it is not so easy to carry out the principle of it in the class room. We may convince students of the desirability of such a method of self-instruction and hold out to them the certainty of success; but few, if any, will put it in practice unless we make it impossible for them to avoid following our instructions. It is the nature of the youthful mind to study all lessons in precisely the same manner—a lesson in languages just like a lesson in geometry. To them, studying means reading a task over and understanding it. The idea of *practicing* has to be enforced.

It will be desirable, therefore, on hearing a reading lesson to direct students to mark and commit to memory certain sentences in such a way that they can repeat them the next day fluently and naturally after reading them over once. Any hesitation or false emphasis should be considered a failure. Then questions might be prepared to compel students to combine their newly acquired vocabulary in various ways.

By judicious selection, they will soon accumulate enough material to enable them to narrate in their own phraseology simple stories and anecdotes and eventually to condense longer narratives, to paraphrase poetry, and to write compositions.

I consider it very important to begin with the literature of the present day, and not to meddle with classical writers until the daily newspaper no longer presents any difficulties. Then the student may approach the classics on a footing of equality with a native. Those who imagine that they are enjoying a foreign classic while they have to dig out the meaning laboriously are only deluding themselves. What they enjoy, if they honestly get any pleasure in the process, is the thought of the writer as conveyed in their own rendering, and perhaps also the satisfaction of overcoming difficulty. They certainly cannot enjoy the beauty of the original.

HEBE AND AMOR FEEDING THE PIGEONS OF VENUS—SCULPTURED BY PROF. F. SCHAPER.—*Illustrirte Zeitung.*

THE CHINESE WALL A FACT.

By Rev. J. H. ROBERTS, of Kalgan, North China.

To one who has lived close by the Chinese wall, seeing it every day, and often climbing over it and examining it minutely, it is very amusing to see its existence questioned. A pamphlet has been issued in Paris by Abbe Larrieu, which has been quoted by several papers in the United States, the object of which is to show that though there are scattered towers along certain passes, there is no such thing as "the great Chinese wall." The whole story of such a structure is pronounced a fancy and a myth. But this wall is no more a myth than are the pyramids of Egypt or the Bunker Hill monument.

As one goes northwest from Peking, he first sees the great wall when in the Nankou Pass, at a distance of thirty-seven miles from Peking. It is made of earth faced with several layers of large brick, and rests on a foundation of cut stone, like the walls around cities commonly seen in China. But this wall asserts its individuality by stretching right away on each side of the valley, up steep slopes, and from peak to peak, till it is lost to view at the top of those high and picturesque mountains. In the pass is the view of the wall commonly given in books. One sees at a glance what herculean efforts must have been put forth to raise so much brick and mortar to such heights, and build it there—a great work of national defense at the time, and a wonder for all subsequent ages to behold. A proverb says that "Building the great wall spoiled one generation, but saved a thousand."

Going on up the valley, one sees several forts built like the great wall, but not extending far up the mountains. At the summit of the pass is another branch of the wall, which follows the highest ridge of that great mountain chain, stretching off to right and left as far as one can see, climbing every peak of the divide. The wall here is not much ruined, and has about the dimensions given in Williams' "Middle Kingdom," namely, twenty-five feet thick at base, fifteen feet thick at top, and from fifteen to thirty feet high. The varying height is due to the fact that the top of the wall does not follow all the inequalities of level at the base. On the south side are a few arched doorways, to admit the soldiers who were to defend it. As one passes the little city of Ch'a Tao, and follows the road toward Kalgan, he begins to cross a gravelly plain, about twenty miles wide. Then looking back toward the east, he has a distant but fine view of the great wall. If the weather is good, the wall almost gleams in the sunshine, extending like a light gray ribbon along the ridge of the mountains, waving up and down, reaching from summit to summit, surmounted at its highest points by a square tower that stands out against the sky, defying wind and weather, as it once defied the Mongol hordes. The wall stretches away from Ch'a Tao to the southwest, and the eye can follow it for twenty or thirty miles, except where it crosses deep valleys or is hidden behind the nearer peaks. At the foot of the mountains is a row of towers only about two hundred feet apart, which the eye can trace for a distance of nearly thirty miles, to a point where it enters a valley and is lost to sight among the mountains. These towers probably mark the line of an old military road occupied by the outposts of the soldiers who were defending the wall. Every third tower is faced with brick, and might have had a house built on the top of it, as some of them certainly had, in which, if necessary, sixty soldiers could live. Perhaps the Abbe Larrieu, who declares the great wall a myth, saw only these towers, and did not lift his eyes to the mountain tops. Or he may have ridden through the pass in a mule litter, the windows of which are too low to give one a sight of the mountains. Or M. Larrieu may have been absorbed in reading a book. But how can he affirm from what he has *not* seen, that what many others *have* seen is a lie and a myth?

But, leaving the region above described, and going on to Kalgan, one reaches the more ancient branch of the great wall. There is the genuine wall erected by the haughty Emperor Ch'in Shih Huang, B. C. 21-204. It is great in length and antiquity, but not great in any other respect, except in the vast labor and expense and the number of lives it must have cost. The sight of it is disappointing. It is only about fifteen feet high, and twelve feet thick at the base. Its sides curve inward as they go up, and the ridge at the top is less than a foot thick, too thin in many places for a man to stand upon it without difficulty. It is built of irregular blocks of stone, dug out of the ground on the outer (that is, Mongolian) side, by which the level of the ground on that side was lowered, and the relative height of the wall increased. We are told by a geologist, Mr. Hague, who visited Kalgan, that the rocks there are mostly a porphyritic trachyte. It is a porous kind of rock, evidently of volcanic origin. The builders of the wall used whatever materials were most convenient, and, therefore, different kinds of rock in different localities, and where rock was scarce, they used earth hardened by pounding—generally the yellow earth of the loess formations. Short portions of the wall near Kalgan have lime between the stones, but as this is not the case elsewhere, these parts must have been rebuilt at some later time. The old brick towers on the wall near the city are quite picturesque.

From the mission premises of the American Board at

Kalgan, the wall can be traced from a point five miles to the northwest, following the ridge of the mountains, to the northern end of the city, then climbing the side of Mount Williams to its peak (forty-five hundred feet above the sea, and eighteen hundred feet above Kalgan), and again following the ridge of the moutains away to a still higher peak called Mount Jacob, ten miles to the east. This ancient branch of the wall is much broken down, and in many places is merely a long heap of stones. But it can be identified at any place by the towers near it, and by its habit, so to speak, of following the divide, and of climbing the most inaccessible peaks.

I have crossed this wall in eight different localities besides Kalgan, and will note them in their order, going from west to east.

1. At Te Sheng K'ou, Shanse, one hundred and twenty miles west of Kalgan, the wall is made of pounded earth. I followed its course for several miles, and found some parts of it were thirty-five feet high.

2. At H'sin P'ing K'ou, fifty miles west by southwest from Kalgan, where it is also made of earth, fifteen to twenty feet high.

3. At Hanore, fifteen miles northwest of Kalgan, the wall looks like a long heap of stones thrown loosely together. Here the level is over five thousand feet above the sea.

4. At Ta Pai Liang, fifty-seven miles east of Kalgan, the wall is like that at Hanore, only still more ruined.

5. At Chuang K'o Li, a few miles north of Ta Pai Liang.

6. At a place eight miles west of Tu Shih K'on, and sixty-seven "long miles" northeast of Kalgan, where the wall is like that at Hanore.

7. At Hun Sha Liang, ninety miles due east of Kalgan, I crossed the wall without knowing it. Probably the road was worn down at the top of the hill, till it resembled a ditch, the sides of which prevented my seeing the wall. During the rest of that day, which was June 21, 1883, we were uncertain which side of the wall we were on, the map and the people whom we met agreeing in saying that we were in Mongolia, but our feeling was that we were in China proper, because we had not seen the wall when we crossed it. But at sunset we crossed it again.

8. At Shang Pu, from north to south, and then we knew that we were entering China proper from Mongolia, and that we *must* have crossed the wall at Hun Sha Liang without knowing it. The wall here resembles that at Kalgan, climbing the mountains in both directions.

This completes the list of places where I have crossed the great wall, but I have seen it in the distance from many other places, and the distance between the extreme parts of it that I have seen is two hundred and sixty miles.

Of the Chinese who live close by the great wall—under its shadow, if you please—there are two classes of people who never know it nor see it, namely, those who are blind, and those who are very busy—too much absorbed in their business to study the mountain tops. But neither class would ever think of pronouncing the great wall a myth.—*Missionary Herald.*

NOTES ON ETHEREAL OILS.*

1. *Nature and Occurrence.*—The aroma of plants is, in most cases, due to the presence of strongly odorous constituents, which are termed ethereal (or essential, or volatile) oils if they are liquid, and stearoptens or camphors if they are solid. The latter are always crystallizable, though many of them are odorless and tasteless.

The leaves, barks, and seeds of many plants from the families of Pomeæ and Pruneæ (Amygdaleæ), which, of themselves, are odorless, furnish, when they are comminuted and macerated in cold water, a peculiar, strongly smelling mixture of benzaldehyde and hydrocyanic acid, which is commonly designated as oil of cherry laurel or of bitter almond. Mustard seed, which is likewise colorless, furnishes oil of mustard only after a splitting up of the sinigrin. It would, therefore, be quite proper to exclude these liquids from the class of ethereal oils.

This convenient term cannot be sharply defined. With the exception of oil of mustard, probably all other so-called ethereal oils are likewise mixtures of several compounds. In some plants, as, for instance, in cinnamon, various species of citrus, members of the pine and labiate family, the oils derived from different organs of one and the same plant are not identical.

Most ethereal oils are known to possess an agreeable odor. In some cases, however, this may be declared without doubt as repulsive. Among the plants which diffuse a disagreeable odor when their leaves are crushed may be quoted as examples several species of *Ferula*, *Melianthus*, *Eucalyptus pendula*, *Allium* and *Umbellularia* (*Oreodaphne*) *californica*. Many flowers, f. i., those of *Ailanthus glandulosa*, *Ceratonia Siliqua*, *Cratægus*, and also some kinds of wood, likewise exhale bad odors.

From the domain of cryptogams, only few of which have an aroma, no ethereal oil has so far been made known. There are also some phanerogamic families, as the Palms, the Polygonaceæ, Malvaceæ, Gentianaceæ, and Liguliforæ (among the Compositæ), which do not yield ethereal oils. On the other hand, certain other families are remarkable through their great richness, f. i., the Abietineæ, Zingiberaceæ, Piperaceæ, Myrtaceæ, Lauraceæ, Dipterocarpaceæ, Rutaceæ, Umbelliferæ, Labiatæ, and some sections of Compositæ. Very large quantities of ethereal oils are likewise produced by the numerous eucalyptus trees of Australia and the species of citrus of Southern Europe and India.

It is generally possible to distinguish special receptacles in or upon the different organs of plants which contain the ethereal oils. In the first eight among the above mentioned families, for instance, these receptacles lie in the inner cellular tissue. In the Labiatæ, however, and also in many Compositæ, they are situated as sessile or pediculated glands upon the epidermis.

In the tissue of sandal wood (from Santalum album and other species), which contains considerable of oil, no special oil receptacles are found. And in many plants yielding only minute quantities of oil, such as the flowers of Rosa, Sambucus, Tilia, etc., the domicile of the ethereal oil has not been made out.

The largest proportion of ethereal oils is afforded by the so-called balsams and turpentines (which are mixtures of resin and ethereal oil), also by gum resins. Very rich in oil are also cloves, caraway, and other umbelliferous seeds, and the rinds of lemons.

The animal kingdom does not afford any ethereal oil.

2. *Preparation.*—Though the boiling points of the compounds belonging to this class (excepting abietene) are considerably higher than 100° C., they are nevertheless abundantly volatilized with steam, and are mostly obtained by distillation with water. But in the case of species of citrus, it is sometimes preferred to extract the oil, from the cells which contain it, by pressure, because the delicacy of the aroma is injured through distillation.

The preparation of essential oils is often carried out with the most simple contrivances, when small quantities are to be prepared, or when the crude material is to be worked up at once at the place of growth. . . . In large factories, the manufacture of the ethereal oils is carried on, with the aid of steam, on the largest scale, with utilization of every available technical invention. Recently, vacuum apparatus is also employed, so as to extract the oils with the least possible alteration.

During the distillation of ethereal oils it happens sometimes that fatty acids pass over. So, for instance, in the case of that of laurel, nutmeg, orris, capsicum, and tea. The small quantities of these fatty acids may possibly be derived from compound ethers (esters), either through the decomposition, by the boiling water, of fats existing in the plant, or due to the presence of esters belonging to the series of monatomic alcohols, which pass over along with the ethereal oils. When such esters are decomposed in the course of the distillation or rectification, the oil, which was previously neutral, acquires an acid reaction, as, for instance, oil of valerian, etc.

Otherwise, the development of acids in ethereal oils is due to gradual oxidation by exposure to air. This occurs most prominently in oil of cinnamon.

The oils which are obtained by pressing, at least oil of bergamot, contain minute proportions of chlorophyl.

3. *Properties.*—Odor and taste of the ethereal oils correspond to the aroma of the plants from which they are obtained, though often with some difference.

The stearoptens are colorless, likewise a large majority of ethereal oils. But many of them, when freshly prepared or after being exposed for some time to the air, present a yellowish, brownish, or deep brown color, and can be rendered colorless by rectification. Some oils have a peculiar more or less pure bluish green tint, often covered by a brown one, for instance the oils of *Artemisia Absinthium*, *Achillea Millefolium*, *Achillea moschata*, calamus root, chamomile flowers, arnica flowers and root, the root of Asarum Canadense and Asarum Europæum, caraway seeds, cascarilla bark, etc.

Blue oils are obtained by distilling the following drugs or their oils: Sumbul root, German chamomile, pichury seed, patchouly herb, valerian root, etc., etc. The North American sage brush (*Artemisia Ludoviciana* Nutt. ?) likewise yields a fine specimen of oil belonging to this class.

When such oils are rectified, the first fractions coming over are colorless, the next are brownish, then greenish, and finally, in most cases, deep blue, which are often again followed by less deeply colored drops. . . . This magnificent blue color is afforded particularly, and from the very beginning, by the oil of German chamomile (Matricaria), . . . and still more so by empyreumatic oils obtained by the dry distillation of asafœtida, galbanum, and sumbul root. These blue oils are probably identical with each other.

Certain green oils derive their color from chlorophyl, particularly oil of bergamot.

A fine yellow color is characteristic of oil of turmeric.

A few ethereal oils are fluorescent, for instance, that of sage, neroli, etc. The most magnificent fluorescence is produced in oil of peppermint, if it is shaken with glacial acetic and nitric acid. . . .

Ethereal oils possess different degrees of fluidity. While most of them are very mobile, others are viscid, particularly those which correspond to the composition $C_{15}H_{24}$ or $C_{20}H_{32}$, but not those of the formula $C_{10}H_{16}$. Among the more viscid oils are oil of copaiba, cubebs, poplar buds, pepper, olibanum, sandal wood, and the specifically lighter portion of oil of cloves. The residues remaining after the rectification of many ethereal oils are likewise quite viscid and appear to be formed by polymerization, that is, by the coalition of several molecules.

Most ethereal oils attack cork stoppers, and bleach the latter through the formation of ozone.

The specific gravity of the large number of ethereal oils of the composition C_5H_8 and its multiples is less than that of water, and varies between 0·850 and 0·980. Some of the naturally occurring oxygenated oils possess a higher spec. gravity than water, as the oil of Asarum Europæum (1·018), oil of cloves, cinnamon, and sassafras. The oil of parsley fruit splits at 15° C. into a lighter portion floating upon water and into a heavier portion (sp. gr. 1·140) sinking to the bottom. Oil of arnica root sinks in water between 0° and 15° C., and floats upon warmer water. Heavier than water are likewise the oils of Hysopus officinalis and of Mentha Pulegium; so also oil of mustard, bitter almond, and gaultheria.

Very many oils are mixtures of hydrocarbons with oxygenated portions. The latter always have a higher specific gravity, the determination of which is of practical importance, because the oxygenated portion is, in all cases, the real bearer of the valuable properties (particularly of the odor) of the oil. Carvol is the desirable portion of oil of caraway, having the spec. gr. 0·960. The finest oil of peppermint, richest in menthol, has the spec. gr. 0·920. Where the manufacturer removes the hydrocarbons of the ethereal oils, the latter become very materially improved in aroma and rendered more concentrated in valuable constituents. In such oils, the specific gravity itself serves as a criterion; the nearer to 0·960 an oil of caraway is, or the nearer to 0·920 an oil of peppermint, the more valuable will it prove to be. . . . [The portion now following, relating to melting and boiling point, polarization, is for the present omitted.]

Ethereal oils are miscible with a large number of liquids in any desired proportion. For instance, with anhydrous alcohols, esters, many organic acids, ether, chloroform, acetone, carbon disulphide, etc. But there is a considerable difference in the behavior of the non-oxygenated and the oxygenated portion of an ethereal oil toward alcohol. The latter, even when considerably diluted with water, can dissolve very notable quantities of the oxygenated portions of oils. The hydrocarbons, however, particularly those of high boiling point, often require several times their volume of alcohol (sp. gr. 0·830) to produce a clear solution. It must be remembered that freshly distilled oils behave different from older, resinified oils, which latter are more easily soluble in alcohol.

4. *Composition of Ethereal Oils.*—Many ethereal oils have the ultimate composition represented by the formula C_5H_8, but their vapor densities and some other observations render it probable that some of them are constructed after the formula $C_{10}H_{16}$, and others again after the formula $C_{15}H_{24}$, or $C_{20}H_{32}$; some of them are mixtures of these hydrocarbons. Most ethereal oils belonging here are attacked by metallic sodium, and are therefore apparently accompanied by oxygenated oils, which are no doubt often present only in minute quantities. Curiously enough, the formula C_5H_8 belongs also to gutta percha, caoutchouc, and that portion of dammar resin which is soluble in absolute alcohol; yet the molecule of these bodies must be expressed by a multiple of the formula C_5H_8. At a higher temperature, however, they yield the simple compounds, C_5H_8 and $C_{10}H_{16}$, of a fluid consistence.

On the other hand, hydrocarbons corresponding to the two last mentioned formulæ, when exposed to a moderate and protracted heat, are transformed into denser and less volatile, so called *polymerized* compounds. Polymerization appears to occur, for instance, during the rectification of many ethereal oils, as they leave behind viscid residues. This occurs particularly if they are distilled without steam.

Among the very large number of ethereal oils which are certainly constituted according to the formulæ $C_{10}H_{16}$, several groups may be distinguished, especially if the classification is made to include also the *terpenes* which are prepared artificially from naturally occurring oils and resins. The term *terpene* is commonly applied to ethereal oil having the composition $C_{10}H_{16}$. Some of these compounds are solid, melt at 50° C., and boil below 150° C. The liquid terpenes, boiling near 160° C., form only liquid compounds with bromine. On the other hand, a large number of terpenes boiling at about 176° C., when combined with bromine, yield crystals ($C_{10}H_{16}Br_4$) melting at 105° C., as, for instance, the hydrocarbons occurring in the oils of species of citrus, of caraway, dill, etc. A number of other terpenes, for instance, those of oil of Levant wormseed (cinene), oil of cajeput, and also those produced by heating caoutchouc, boil between 180° and 182° C., and form crystalline bromine compounds ($C_{10}H_{16}Br_4$) having a higher melting point, viz., at 125° C.

The terpenes combine with dry hydrochloric acid gas to crystals having the composition $C_{10}H_{16}HCl$ or $C_{10}H_{16}(HCl)_2$, at the same time assuming a dark color even if they are kept cold. The acid gas is best prepared by allowing sulphuric acid of spec. grav. 1·840 to flow gradually into hydrochloric acid of spec. gr. 1·170.

Ethereal oils of the composition $C_{15}H_{24}$ or $C_{20}H_{32}$ yield no solid compounds with hydrochloric acid.

Under certain circumstances, probably all ethereal oils of the composition $C_{10}H_{16}$ (but not the others having the same percentage composition) combine with three molecules of water to a body which is probably identical in all cases, viz., *terpin*. This occurs also naturally, for instance, in the trunks of *Dryobalanops aromatica* Gaert., also in some Californian pines, and is occasionally deposited by the oil of *Ocimum Basilicum* L.

Another hydrate, namely, $C_{15}H_{24}.OH_2$, is represented by the stearopten of cubebs. From elemi are obtained *amyrin*, $(C_5H_8)_4OH_2$, and *bryoidin*, $(C_5H_8)_4 3OH_2$. Some oils, as those of rosemary and lemon, and the hydrocarbons of oil of dill and oil of cajeput, easily yield the above mentioned crystals [of terpin hydrate]; other oils, such as that of elemi and carvene, with greater difficulty. But even in such cases it may be obtained by placing only a thin layer of the oil upon the diluted acid.

[From a subsequent chapter we insert here the method of preparing *terpin hydrate:* On mixing together in a capacious flask at the ordinary indoor temperature 1 part of nitric acid (sp. gr. 1·200), 2 parts of alcohol (sp. gr. 0·830), 4 of water, and 8 of oil of turpentine, it requires a period of one to two years to convert about 18 per cent. of the oil of turpentine into terpin hydrate in form of large, well developed, and but slightly colored crystals belonging to the monoclinic system. The greater the surface of contact between the oil and the lower aqueous layer, the more rapid is the production of terpin. On pouring a mixture of 1 part of alcohol, 1 of nitric acid, and 4 of oil of turpentine into flat dishes, it requires only a few days to obtain 20 per cent. of terpin hydrate from the oil. It is of advantage afterward to partially neutralize the acid. Strong light, and also heat, retard the formation of the substance.]

Some oils, of the same percentage composition as the terpenes correspond to the formula $C_{15}H_{24}$, as is shown by their vapor density. The oils of this class also possess a higher specific gravity, a higher boiling point, a lesser degree of miscibility with alcohol, and yield other oxidation products.

Some oils, as those of *Cicuta virosa* L., *Thymus vulgaris* L., *Cuminum Cyminum* L., *Monarda punctata* L., contain also cymene (cymol) which is identical with the same body (cymene) artificially prepared from the oils having the composition $C_{10}H_{14}$. This cymene does not form crystals either with hydrochloric acid or with water, but with fuming sulphuric acid it yields the crystallizable, deliquescent cymene-sulphonic acid, $C_{10}H_{13}$-SO_2OH.

Besides hydrocarbons of the composition C_6H_7 and C_6H_8, oil of rose contains a crystallizable hydrocarbon belonging to the class of paraffins [or saturated hydrocarbons].

Small quantities of such bodies have also been found in the ethereal oils of the orange family and in the fruits of Heracleum and Pastinaca. The turpentines of the Californian *Abies Sabiniana* Douglas and *Abies Jeffreyi* yield a considerable quantity of a heptane, C_7H_{16}, of the spec. grav. 0·694. This body, named *abie-*

* Translated, and partly abstracted, from the second, enlarged edition of Prof. F. A. Flueckiger's *Pharmaceutische Chemie.*—*American Druggist.*

tene, boils at 98·4° C., has a strong odor of orange, and turns the ray of polarized light to the right.

Many oils are mixtures of hydrocarbons (C_5H_8) with oxygenated oils. The name of the former are usually made to terminate in *-ene* [in German in *-en*], and those of the latter in *-ol*. For instance, oil of caraway consists mainly of

carvene, $C_{10}H_{16}$, and
carvol, $C_{10}H_{14}O$;

oil of thyme, of thymene and thymol. Hence the body which has been called cymol should be rather named cymene.

The oxygenated oils and stearoptens possess a very varied composition; most of them contain only 1 atom of oxygen, for instance:

$C_{10}H_{12}O$—anethol.

$C_{10}H_{14}O$—carvol, carvacrol, thymol, myristicol, eucalyptol, cumin alcohol.

$C_{10}H_{16}O$—common camphor, oils of *Mentha Pulegium* and *Artemisia Absinthium*, *citronellol* (from *Andropogon Nardus* L.); stearopten of the oil of *Chrysanthemum Parthenium* Pers., caryophyllin, inula- (or alant-) camphor, and alantol or (inulol), and urson from *Arctostaphylos* and *Epacris*.

$C_{10}H_{18}O$—Blumea camphor, amber camphor, Borneo camphor. This formula also belongs to the liquid existing in many ethereal oils, sometimes constituting their major portion, for instance in that of oil of wormseed, cajeput, and eucalyptus globulus. This body, named *cineol*, is also probably found in the East Indian lemongrass oil (from species of *Andropogon*), and in the oil of *Osmitopsis asteriscoides* Cassini.

$C_{10}H_{20}O$—menthol, the crystallizable portion of oil of peppermint.

$C_{12}H_{20}O$—the stearopten of oil of matico.

$C_{15}H_{26}O$—the stearopten of oil of patchouly.

The following are richer in oxygen:

$C_{28}H_{44}O_2$—the stearopten of the oil of *Ledum palustre* L.

$C_{10}H_{10}O_2$—saffrol from sassafras.

$C_{10}H_{10}O_3$—cubebin.

$C_{12}H_{14}O_4$—parsley camphor.

$C_{22}H_{24}O_{10}$—stearopten from oil of Primula.

Only a few oils are aldehydes, in a chemical sense; for instance, oil of bitter almond, $C_6H_5.CHO$. The chief constituents of oil of cinnamon, cumin, and Spiræa likewise belong to this class, which unites with the bisulphites of alkalies to crystalline compounds. Some other ethereal oils, as that of peppermint, ylang-ylang, and citronella, also contain small quantities of aldehydes.

Oil of rue also contains a body yielding a crystalline compound with bisulphites, but this belongs in the class of the ketones. . . .

Alcohols [in a chemical sense, viz., methyl and ethyl alcohol] have been met with in the ethereal oils of many umbelliferous fruits, . . . and in some others, compound ethers (esters) are found. For instance, salicylate of methyl in the oil of *Gaultheria procumbens* (etc.) The oils of the fruits of *Heracleum giganteum* and *H. Sphondylium* L. contain a whole series of compound ethers of fatty acids with the hexyl and octyl radicals. . . .

Among the constituents of the oils of *Lepidium sativum* L. and *Tropæolum majus* L., the combination C_8H_7N has been recognized as the nitrile of phenyllactic acid ($C_6H_5.CH_2.COOH$). When boiled with alcoholic potassa, this eliminates ammonia, and hydrochloric acid precipitates phenyllactic acid from the solution. . .

Isosulphocyanates are represented among the ethereal oils by fractions contained in oil of mustard and Cochlearia, which contain a large percentage of sulphur (like garlic). . . .

Compounds belonging to the class of phenols occur as chief constituents in the oils of anise, staranise, fennel, estragon, cloves, and thyme, and small quantities also in those of calamus and sassafras. At least, fractional distillation is able to separate from these certain portions which are colored violet or green by alcoholic ferric chloride. Very curious is the ease with which carvol may be converted into a phenol.

Under the influence of *air* and *light*, and also that of *heat* during distillation, ethereal oils suffer certain changes which are comprised under the name *resinification*. They acquire, thereby, a viscid consistence, and finally become quite stiff and almost solid. But the changes occurring during this process have not yet been fully made out. None of the resins thus produced appears to occur in nature. . . .

INFLUENCE OF MAGNETISM UPON CRYSTALLIZATION.

By C. DECHARME.*

AFTER studying the role of electricity in crystallization,† it was very natural that I should examine the influence of magnetism under analogous conditions; not, however, with a view of proving the manifestation of magnetism by the fact of crystallization, but rather of showing the direct influence of magnetism upon the phenomenon itself.

Various experimenters (Brugmann, Coulomb, Lebaillif, Deleese, Seibeck, Becquerel, Plucker, and others) have proved that magnetism exerts a more or less marked influence upon certain substances other than iron and its congeners. Faraday has demonstrated that such influence extends to all bodies, and that crystalline ones do not escape the general law.

Only a few years ago, says Mr. Tyndall, magnetism was but an occult force affecting only a very small number of bodies. We know now that it influences all bodies, and that it has most intimate relations with electricity, heat, chemical action, and crystallization, and, through the latter, with all the forces set in action by cohesion.

Magnetic Crystals.—In order to explain the regular forms that crystallizable substances affect, Mr. Gaudin grants that their molecules are formed of atoms arranged, not in spheres or cubes, but that each of them is a symmetrical aggregation of chemical atoms, which would imply the clustering of the component atoms, whatever they be, to form a new arrangement having no relation with the form of the components.

Instead of placing themselves in equilibrium in all directions, the chemical atoms balance themselves only in two directions, at right angles with each other—one parallel with the axis of the grouping, and the other at right angles with it.

Thus, in each molecule, the atoms are ordinate with respect to the same straight line, which is the real or imaginary axis. From these views to the conception of the polarity of crystals and to their influence by magnets there is but a step.

From numerous experiments made by Messrs. Plucher and Beer, Knoblauch and Tyndall, it seems to result that in crystallized substances which do not belong to the first crystalline system, the crystallographic axes exert a certain influence upon the development of the magnetic polarity. In the crystals of the five last systems, there are certain directions that are attracted or repelled by the electro-magnet with more force than all the others, and that thus become magnetic axes with crystals. The latter, in fact, tend to direct themselves between the poles of the magnet in a manner that is peculiar to them and independent of the artificial form that may be given them; and if, in order to annul the influence of such form, we render it spherical, we observe the crystallized body to turn itself in such a way as to place one of the fundamental lines of its structure in the line of the poles, or in a direction at right angles.

FIG. 1.

When we see crystals attract each other in certain directions, and repel each other in others, we cannot refuse to allow that the atoms, and consequently the molecules, are possessed of polarity.

In crystallized substances, magnetic polarity tends to develop in fixed directions, while in non-crystallized substances the direction of the line of the poles is not at all fixed, but varies with the form of the atoms. What varies the form of crystals is the very nature of the molecules in which the poles are differently arranged.

Crystals are due to the play of the polar forces of which the molecules themselves are possessed. By virtue of these forces, molecule places itself alongside of molecule in a definite manner, and the visible form behind the crystal depends upon the play of the molecules. Everywhere in nature do we observe this tendency to run toward definite forms.

On the subject of magnetic crystals, Mr. Tyndall says: Organic bodies and most crystals are magnetic to various degrees of intensity in different directions. They have axes of magnetic induction. Thus, in the case of spar (carbonate of lime), repulsion in the direction of the axis is maximum. In carbonate of iron, a crystal of the same form and structure as carbonate of lime, attraction in the direction of the axis is minimum. The position taken by a crystal suspended between the poles of a magnet depends upon its magnetic axis.

It is well known that segments of tourmaline behave like the entire crystal, that is to say, they are possessed of the property of the total magnet. In general, then, crystals are formed of molecules possessed of polar forces.

Again, Mr. Tyndall says: The atoms and molecules of which crystals are formed have definite poles whence issue attractions and repulsions for other poles. By this play of invisible particles we see rise before our eyes those exquisite structures that we call crystals.

After the researches of Tyndall, Rowland, and De Stenger, upon the magnetization of crystals, Mr. Koenig published in the *Annales de Wiedemann* (vol. xxxi., p. 273) a memoir that has already been reviewed in this journal. We shall merely say that the author's method consists in suspending the substance to be studied from a cotton thread, between the armatures of a powerful electro-magnet, and in measuring the deflection that the substance undergoes under the influence of the magnetic field. The substance, in the form of a sphere, tends to place its axis of magnetization at right angles with the lines of force of the field. The author has applied his method for determining the principal constant of magnetization of crystals of spar for magnetic fields reaching 3,000 C. G. S. units.

The mechanism of crystallization becomes really intelligible only on our granting that the constituent molecules of crystals are possessed of poles, and, consequently, of attraction on certain sides and of repulsion on others.

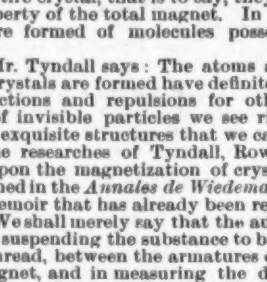


FIG. 2.

FIGS. 1 AND 2.—EFFECT OF MAGNETISM UPON CHEMICAL ACTION.

Without advancing any theory on the cause of magnetism (which is still unknown), the phenomenon of crystallization would, in fact, be inexplicable if we did not admit that the constituent particles of crystals are possessed of electric polarity, or, what is the same thing, magnetic polarity. If, then, we are obliged to admit polarity in molecules, it would be illogical to refuse to believe in the influence of magnetism upon crystallization. It is only a question now of putting the phenomenon in evidence and determining the conditions most favorable for its manifestation.

Influence of Magnetism upon Chemical Action.—Before approaching the question of the direct influence of magnetism upon crystallization, it will be well to recall some experiments tending to prove the influence of magnetism upon chemical action.

Just as in our study of the role of electricity in crystallization we distinguished the action of electricity upon chemical action and crystallization (*i. e.*, upon affinity and cohesion), just so we shall here distinguish the effects of magnetism upon chemical action and crystallization.

The influence of magnetism upon chemical action was demonstrated by direct experiment several years ago, and has been again demonstrated quite recently in a manner that leaves no room for doubt.

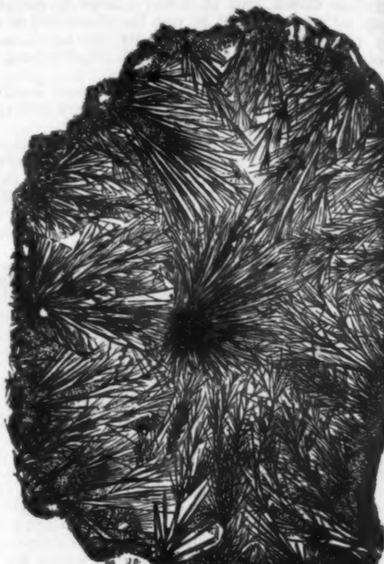


FIG. 3.

In 1881, Mr. Ira Remsen, of the Johns Hopkins University, made various interesting experiments on this subject that we shall briefly describe: A solution of sulphate of copper was poured into a thin iron vessel, and the metal was observed to deposit throughout the whole extent of the surface of the iron covered with the liquid. But, when the iron vessel was placed upon the poles of a strong magnet, the deposit of copper did not occur upon the limits of the poles. At these points, and here only, there was a depression of the deposit. Moreover, around the poles were seen lines that appeared to be at right angles with the lines of force, that is to say, having the direction of the equipotential lines. These effects were not at first explainable.

In 1883, Mr. H. V. Juepner took up these experiments. Fig. 1 gives, in horizontal projection and vertical section, the effect depression produced opposite the poles of the magnet. It must be remarked that the thickness of the cupreous deposit was perceptibly increased in order to render the effect more striking. With a very strong electro-magnet acting by a single pole only, Mr. Juepner obtained the effect shown in Fig. 2, where the lines form concentric circumferences, separating layers of copper of unequal thicknesses, and remaining visible within a radius of two inches.

The author explains the phenomenon as follows: The attraction exerted by the magnet on the iron of the receiver proves an obstacle to the dissolving of the iron, and consequently to the separation of the copper. The result is that the quantity separated is inversely proportional to the magnetic attraction. Thus, it is evident that in the preceding experiment the magnetic attraction at the pole is greater than the chemical action (electrolytic). In measure as we leave the pole, the magnetic action diminishes. The quantity of iron dissolved increases with the quantity of copper deposited. If the magnet is weak, the magnetic action is no longer powerful enough to counterbalance the electrolytic force.

FIG. 4.

FIGS. 3 AND 4.—INFLUENCE OF A MAGNET UPON CRYSTALLIZATION.

I have repeated the fundamental experiment with a vessel made of very thin sheet iron, and a strong Jamin magnet, and have verified the fact that the limits of the poles are very clearly marked in black lines, the rest of the surface of the vessel being covered with a deposit of copper.

This arrangement of chemical deposits, under the influence of magnets, furnished Mr. Colardeau an occasion to make some interesting researches on the magnetic phantoms produced by means of substances that

* In *La Lumière Électrique*.

† See SUPPLEMENT, Nos. 613, 616, 618, and 619.

are but slightly magnetic. These experiments led to an explanation of the phenomenon observed by Messrs. Remsen and Juepner. The following is Mr. Colardeau's final conclusion: If the edges of the polar piece exhibit a thinner deposit than the rest of the plate, it is not due solely to the fact that the iron held there by magnetic attraction dissolves less quickly there than elsewhere, but also in great part to the fact that as the iron salt accumulates there by the sole reason that it also undergoes magnetic attraction, it forms an inactive stratum that acts as a protecting varnish.

Influence of Magnetism upon Crystallization.—The preconceived idea that has guided me in these researches is the following: Starting from the fact demonstrated by Faraday, that crystalline is much more energetic than magnetic force, I endeavored to diminish the former in order to make the latter predominate, or at least to render its effects appreciable, and capable of battling with those of crystallization. To this effect it became necessary to find a means of holding the crystallogenic force in check without, however, paralyzing its energy. It seemed to me that the colloids, which do not crystallize, might, by being mixed in certain proportions with the saline solutions, produce the desired effect. Therefore, before submitting the solutions to the action of magnetism, it became necessary to first

FIG. 5.—INFLUENCE OF A MAGNET UPON THE CRYSTALLIZATION OF SULPHATE OF COPPER.

find out what effect colloids had upon crystallization. I first used gum, and two or three experiments sufficed to show its efficacy.

1. On mixing a solution of acetate of lead with a nearly equal weight of mucilage, and spreading a coat of the mixture over a horizontal plate of glass, crystallization is completely checked, and not a trace of a crystal can be found.

2. On reducing the proportion of the gum to about a quarter, the crystallization of the same salt goes on slowly, and the crystals are small and isolated.

3. When the proportion of the gum is further diminished, the crystals form more rapidly, and are elongated and united in divergant fascicles.

4. Finally, if the gum be almost entirely suppressed, and the solution be concentrated, crystallization takes place quickly in long needles, forming compact, divergent fascicles.

Analogous effects are obtained with other colloids as well as with other crystallizable salts.

Let us now see whether magnetism will have any influence upon crystallization thus held in check.

a.—To a solution of acetate of lead add about one-fifth of its weight of an aqueous mixture of white gum arabic, and spread the mixture over a plate of glass held horizontally over the poles of a strong vertical magnet. Fig. 3 shows the effect that results from the experiment. Around the limits of the poles, which are very close to each other, we see a central mass around which sparkle crystals that radiate in every direction, like the lines of force shown by iron filings under similar circumstances. The S pole appears to have a little more action than the N. Fig. 4 shows effects of the same nature.

b.—With sulphate of copper, under the same experimental conditions, we obtain two masses of slight extent opposite the poles (Fig. 5).

c.—With bichromate of potash the effect is better marked, but the opacity of the crystals does not allow of a sufficiently sharp photograph of the result being taken.

These experiments, and other similar ones, made with various salts, although not giving a complete idea of the influence of magnetism upon crystallization, show, however, that such influence, though feeble, is nevertheless real.

Upon the whole, when we weaken the crystallogenic force by mixing a colloid with the saline solution, we can show the influence of magnetic force upon crystallization; but, for the manifestation of this effect, the colloid must be properly proportioned to the saline solution and its state of concentration.

This arrest of crystallization of a salt in the presence of a colloid in suitable quantity suggests a reflection relative to the limits of action of forces with regard to one another.

The phenomena of the physical world are, as we know, merely the result of the concurrence of the forces of nature, and the variety of these phenomena is due to the predominance or to the concurrence of this or that force. Thus, electrolytic action is impeded by mechanical pressure or by the polarization of the electrodes, and appears to be impeded too by a magnetic power. Crystalline action, as we have just seen, is paralyzed by the presence of a colloid. Magnetic force is modified by the presence of a magnetic body or a colloid. Thus, there is no phenomenon that cannot be more or less masked by another one. We know of few forces that cannot be counterbalanced by another, or by the concurrence of several.

Wishing to know if it were possible also to check electrolytic chemical action completely by the use of colloids, I added a large quantity of gum to a solution of acetate of lead. Upon scattering zinc filings over the mixture the chemical effect occurred in all cases, even with a thick solution, and one entirely capable of crystallizing. Electrolytic is much stronger, then, than crystallogenic force.

We cite the following experiment to the same effect: Gum, mixed with a solution of sulphate of copper in a sheet iron vessel placed upon a magnet, produced in an hour or so cracks in the pellicle of copper that extended in rectangles or triangles. It must be said, however, that this effect does not seem to be entirely due to magnetic force, for, without the presence of the magnet, the phenomenon also occurs, although with less intensity. Moreover, a solution destitute of gum does not produce the cracks on the iron that exhibit themselves when gum is added. Upon the whole, the presence of gum in a saline solution scarcely modifies ordinary chemical effects, except by retarding their manifestation. In fine, the presence of gum, even in large quantity, does not arrest the decomposition of a salt of lead, copper, silver, etc., by zinc filings, but it considerably retards the speed of electrolytic decomposition. It completely arrests crystallization, and it permits magnetic force to exert itself and manifest its influence upon crystallization. On another hand, we know that electro-magnetic force is incomparably weaker than magnetic.

We might represent

Electrolytic	force by	Fe
Crystallogenic	"	Fc
Magnetic	"	Fm
Diamagnetic	"	Fd

and thus formulate their gradation:

$$Fe > Fc > Fm > Fd$$

The preceding experiments appear to establish affirmatively the influence of magnetism upon the crystallization of saline solutions containing a colloid. Although they were undertaken with a preconceived idea, yet I tried them, not in order to justify such idea, but for the sole purpose of discovering the truth. So, on seeing peculiar masses of crystals opposite the poles of the magnet employed in these researches, I have concluded on the efficacy of magnetism and its predominance over crystallization. I had to find whether the fact was general.

In these experiments I have met with several exceptions that have left some doubt on the subject in my mind. I have remarked, in fact, that in certain cases the peculiar crystalline masses are very pronounced opposite the magnetic poles, and that in other cases these arrangements of crystals are not the sole ones that are observed upon the glass plate. However, it must be said that the largest masses were generally located at the poles or in their vicinity. Sometimes they occurred at the south pole only, and at other times opposite the north pole. Sometimes the mass of crystals formed at the pole isolatedly before crystallization had naturally extended thither.

I had to multiply my experiments in order to assure myself that the influence of the magnet upon the phenomenon of crystallization was indeed real. The few exceptions that I met with, with regard to the fundamental fact, were few, it is true, but I propose, nevertheless, to try to verify them under varied conditions, in order to either demonstrate their reality or make them fit into the general law, by varying the proportion of the colloid used in the saline solution.

UNDERGROUND HAULAGE BY ELECTRICITY.

ELECTRICITY has been applied to haulage in various mines. A locomotive car, worked by a current sent through a conductor fixed along the side or the roof of an underground road, could be employed economically wherever the traffic is large and the distance considerable. But there is the objection of requiring a heavy locomotive car, in order to get sufficient tractive power for starting a train of tubs. In a colliery at Zaukeroda, near Dresden, power is generated above ground by a vertical engine, having a 10 in. cylinder with 8 in. stroke, which drives a Siemens dynamo. The current is led to the shaft, which is about 60 yards distant, by two bare copper wires; then down the shaft to a depth of 120 fathoms by well insulted conductors, to the T irons, which run along the roof of the wagon way and form the contact rails, as shown below. The current is picked off these rails by sliding contact pieces fixed to the locomotive, and is led to a switch, which can turn the full current either through the motor or first through reducing resistances and then to the motor. A controlling switch with a seat for the driver is placed at both ends of the locomotive, so that perfect control of the speed and of the starting and stopping of the motor is provided. The length of the line is about 700 yards, and the gauge is 22½ in. A train consists of about fifteen tubs, each carrying 10 cwt. of coal; and the locomotive weighs rather over 30 cwt. The journey takes from three to five minutes, the speed varying from five to seven miles per hour. The plant costs a little above £800, including steam engine, dynamo, motor, locomotive car, conductors, and accessories. It has been working successfully since 1882, and was supplied by Messrs. Siemens & Halske, by whom several other mines in Germany have since been similarly furnished. The working cost of hauling 660 tubs per day of sixteen hours is given by Mr. Rowan as follows:

	s. d.	s. d.
Driver's wages	5 3	
Steam	2 3	
Engine driver at surface	3 1½	
Lubrication, etc	1 1½	
		11 9
Interest and depreciation at 15 per cent. per year of 300 working days		8 1½
Total working cost per day		19 10½

For the output of 660 tubs or 330 tons per day this amounts to only about three farthings per ton.

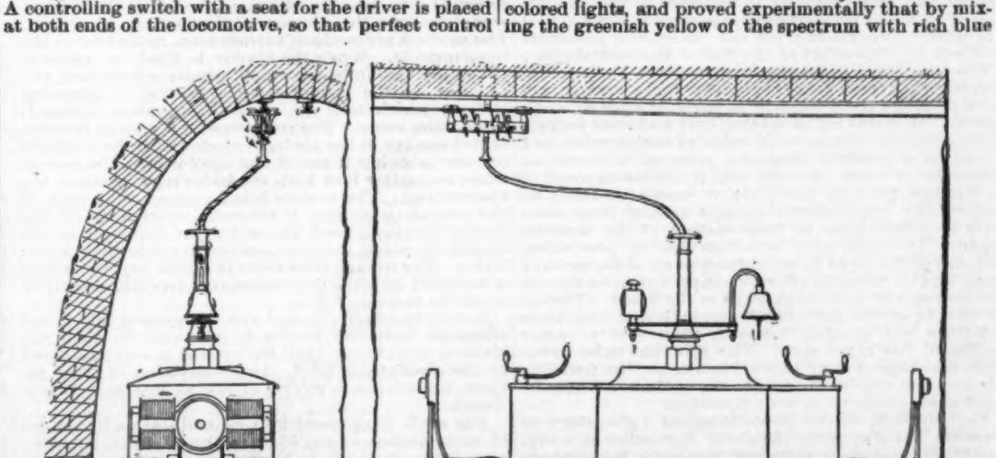
WM. GRIPEL.

EXPERIMENTAL OPTICS.

LORD RAYLEIGH, in a recent lecture upon the above subject, stated that a common lens will not give an exact representation of a white point, because it brings rays of a different color to a different focus; and before the principles of the achromatization were discovered, it was wonderful that the telescopes of Newton's day worked as well as they did. In one way this defect may be readily mitigated by a method which may perhaps be more extensively applied than it has been, namely, by the use of monochromatic light, a plan which Brewster once proposed to apply to the microscope. When lenses are so achromatized as to bring the red and blue rays to the same focus, the focus for green and yellow rays will not be the same with any ordinary media used in the construction of lenses, consequently achromatism in such cases is only approximate. Under the conditions stated, the focus for the yellow and green rays will be longer than for the red and blue; with a simple lens, again, the focus for the red and blue rays will be shorter. Photographic lenses are corrected upon another principle; they are designed in such a manner as to bring the blue rays into focus with the yellow and green, so that the foci for the chemical and chief visual rays shall be coincident. In apparatus for photographing the stars, the conditions are again different; in such case the sharpest possible definition is necessary, and an ordinary photographic lens is for such a purpose not the best, but all the photographic rays must be brought as nearly as possible to the same focus, and the rest of the rays may be neglected. Any one may himself test the achromatism of any ordinary telescope, by bringing the telescope to bear upon any object partly dark and partly bright, such as the edge of a chimney standing out against a bright sky; colors will then be seen near the edge of the chimney; then cover up half the object glass, and the colors will be seen to be different on different sides of the chimney; if all the yellow green rays are thrown to one side, the achromatism is good.

With reflected light the difficulty of non-achromatism never enters; so in this respect reflecting telescopes have an advantage over refractors, but the latter are less liable to give deteriorated images by bending, because if the glass bends on one side, a bend also takes place on the other, and is to a certain extent compensatory. A reflecting telescope having but one surface, such compensation is not possible. Then, again, the surface of a reflecting mirror is liable to tarnish; but, on the other hand, it may easily be made of large diameter, which is not the case with object glasses. Therefore a balance between the advantages and disadvantages of the two instruments has to be struck, the sum total of which probably is that the refractor is best for some purposes and the reflector the best for others. In addition to the difficulty of obtaining perfect disks of optical glass of larger sizes for refractors, increase in the diameter of the refractor necessitates increase in the thickness of the glass, and this increase stops an appreciable amount of light, whereas, when the diameter of a reflector is increased, there is a proportional increase in the amount of light.

The speaker then came to the subject of combined colored lights, and proved experimentally that by mixing the greenish yellow of the spectrum with rich blue



UNDERGROUND HAULAGE BY ELECTRICITY—END AND SIDE ELEVATIONS.

rays, white light was produced; also that a mixture of green and red lights would produce yellow. He stated that white light could also be produced by mixing other colors of the spectrum than greenish yellow and blue, and without using the whole of the colors of the spectrum, which latter plan Newton supposed to be necessary to obtain the result. These effects cannot be obtained by mixing colored paints, the ordinary colors of objects being due to absorption and the stoppage of certain colors by the media. Colored liquids in very thin films will let white light through, and by increasing the thickness of the films, certain colors are absorbed and others transmitted; by still farther increasing the thickness, the liquid becomes opaque; it is all a question of thickness.

Cobalt glass allows the extreme red of the spectrum to pass and makes the spectrum look longer at the red end, because it cuts off the glare of the adjacent rays; with cobalt glass and ruby glass superimposed, only the extreme red of the spectrum passes through. A solution of bichromate of potash absorbs the blue rays with great power. Suppose a medium to be absolutely transparent to all the rays of the spectrum but the extreme red, at certain thicknesses it may transmit a large range of green, which will overpower the red; such a medium is called dichromatic, and chloride of chromium is an example thereof. Lord Rayleigh here exhibited a solution of chloride of chromium in a rectangular glass vessel twice as thick in one direction as in the other; on looking through the sides of the vessel the liquid appeared to be green, and on looking through its ends it appears to be red, hence it would be rather difficult for any one to state the color of the solution. Colors on paper may fairly be compared to the colored glasses laid upon white paper. He here exhibited a flat black dish filled with a liquid the color of which it was impossible to state; it looked black, because there was nothing in it to reflect to the eye the light which had been subjected to absorption. A sheet of white opal glass was dropped into the dish, to throw back some of the light, and the liquid was then seen to be of a bright yellow color.

A NEW ANTISEPTIC.

As was to be expected, our knowledge of the properties of the *oxynaphthoic acids* has now been carried nearer toward finality, in consequence of the numerous experiments which have been made upon them. Messrs. Ellenberger and v. Hofmeister have published a paper in the *Archiv. f. Exper. Pathol. u. Pharmacol.*, detailing their researches and investigations made in the physiologico-chemical laboratory of the veterinary school in Dresden.

The alpha-oxynaphthoic acid (α-naphtholcarbonic acid), $C_{10}H_6 \langle {OH \atop COOH}$ is prepared by bringing together under strong pressure, and at an elevated temperature, α-naphthol sodium and carbonic acid gas. The compound is nearly insoluble in water; 100 c. c. in the cold only take up 0·0535 gramme. The acid sublimes unchanged between 90° C. and 100° C., and melts at 186° C. with evolution of carbon dioxide. It is soluble in the alkalies and alkaline carbonates, forming salts which are colorless, of neutral reaction, and more soluble in both hot and cold water than the acid itself. Thus 100 c.c. at 18° C. dissolves 6·37 grms. of the salts. The acid is precipitated from its salts by hydrochloric, sulphuric, nitric, or acetic acids, but not by carbonic acid gas. Solutions of the salts ultimately decompose when kept even at normal temperatures.

The sodium salt, on the addition of fuming red nitric acid, changes to a beautiful violet or blue color, slowly passing into red, by which reaction the acid may be always identified and distinguished from beta-oxynaphthoic acid, with which it is isomeric, but which with fuming nitric acid affords only a greenish-yellow coloration.

Alpha-oxynaphthoic acid and its combinations with alkalies have been studied by the authors with regard to their antiseptic properties, and also in regard to their effects upon the body in health and disease, and upon the various organs of the animal structure. Fresh meat juice began to putrefy in from about twelve hours when kept at from 37° to 40° C. The addition of 1 : 20,000 of α-oxynaphthoic acid was found to retard the decomposition forty-eight hours, and with a proportion of 1 : 2,500 no bacteria could be detected in unboiled liquids after seven days. When the liquid had been boiled, an admixture of 1 : 1,200 was found to be amply sufficient for the prevention of putrefactive change. In the proportion of 1 : 600 decomposition was stopped in liquids undergoing rapid change. The sodium salt, however, had to be added in the proportion of 1 : 300 to prevent decomposition, and when this was actively progressing, the salt named was powerless to check it. The effect of the β-acid was very similar.

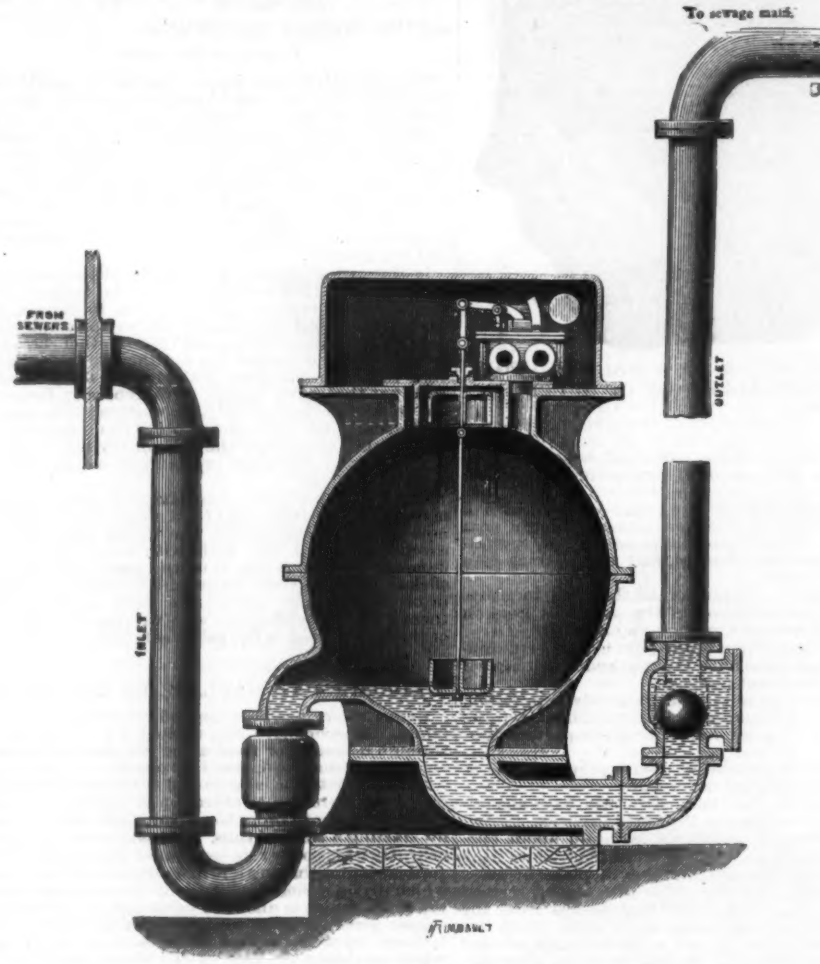
Touching the physiological experiments, the conclusion was that these acids, especially the α variety, are more powerful than salicylic or carbolic acids as antiseptics. It is also indicated that they and their sodium salts particularly may be of value as antipyretics, and would have probably as good a prospect of success as salicylate of soda. As the acid is not decomposed in its passage through the body, it would probably be particularly applicable to diseases arising from some form of putrefaction or fermentation of the internal organs. It would also be of service in preventing changes of the urine in the various parts of the urinary tract, and in treating affections supposed to be due to the presence of micro-organisms in the blood. The experiments, on the other hand, also indicated some toxic influence, not greater, however, than that of other bodies of the same class. The acid has to be given with mucilage or some other demulcent. In parasitic diseases and scabies the acid or the sodium salt may be used as an ointment or with glycerine.

Dr. Lubbert, of the Bacteriological Laboratory of Dresden, has also given details of the action of α-oxynaphthoic acid upon different bacteria. Besides testing it satisfactorily on culture media of varying strength, he inoculated different parts of dead animals, etc., and in all cases the bacteria of putrid urine and meat and of staphylococcus were killed. He found that the micro-organism of anthrax was only affected by aqueous solutions of the acid, with which, however, efficient sterilization was produced. The researches proved that all the spores and germs experimented with were destroyed, and that the anti-bacterial powers of the alpha acid especially were much enhanced by the addition of soft soap. Thus, by a 10 per cent. solution of potassium soap saturated with the acid the germs of anthrax were killed in two days. The experiments of Salkowski, of Berlin, and Kobert, of Dorpat, also coincide with those above alluded to, and it seems likely that in the near future these acids will be introduced into practical use in medicine.—*Chemist and Druggist.*

THE SHONE HYDRO-PNEUMATIC SYSTEM OF SEWERAGE.

THE first step in the system is to divide the district to be sewered into natural drainage areas, these being arranged either by the contour of the ground, by density of population, or other exigencies. The drainage area being defined, its lowest point is located, or, in case of absolutely level ground, its central and most convenient point is determined. Here are centered all the sewage mains of the district, which may be built of the exact required size to accommodate a certain number of people, and which can be laid at any required grade. As the district will be only a portion of the total land to be sewered, it may be seen at once that better gradients may be secured on the district sewers than could be secured on a sewer which would serve the whole town.

At the central point determined upon, called the "ejector station" in the nomenclature of the Shone system, is placed in one of Shone's "pneumatic ejectors," one of which is shown in the accompanying illustration.



SHONE'S PNEUMATIC EJECTOR.

In practice, the sewerage from the district is finally collected into one pipe, shown at the left of the ejector, and flows into the ejector at the bottom, as shown. The ejectors are made in various sizes, according to the requirements. When the ejector is filled, an automatic action is established which admits compressed air, brought to the ejector from a central compressing station, which may be, as at Eastbourne, England, three miles away. The compressed air acts on the contained sewage in the air-tight ejector with the requisite pressure, driving it out of the ejector into the sewage main, no matter how high the latter may be above the ejector level. The sewage being ejected, the action of the automatic gearing is reversed, which cuts off the supply of compressed air, and permits the air in the ejector to escape into the sewers, to aid in their ventilation. The sewage then flows in again, and the action is repeated as often as is necessary, depending entirely upon the volume of flow.

It will be observed that the compressed air is not admitted until the ejector is full, and the air is not allowed to exhaust until the ejector is emptied down to the discharging level. In consequence of these actions, the sewage is got rid of just as fast as it is produced.

The air is compressed in a central station by the use of steam boilers or gas engines, the air, after compression, being stored in iron receivers or in the air mains themselves, if of sufficient length. It is carried to each ejector in small iron pipes.

The sewage mains may, with the Shone system, be smaller than with any other systems, as the grades which render them self-cleansing can readily be obtained.

The system is also particularly applicable to hospitals, asylums, villas, hotels, or other large buildings which are located a considerable distance from the sewer, or where it is desired speedily to remove the sewage some distance away from the building, to irrigating fields, or other methods of disposal.

The ejectors are self-cleansing, self-ventilating, and form complete barriers to the passage of sewer gas from the main sewers back into the district sewers, or, when the system is used for isolated houses, from securing entrance to the house drainage systems.

By the use of the pneumatic ejector, basements can be thoroughly drained, even when far below the main sewer. This drainage is positive even when the sewers are charged with storm water, in which condition the system of sewerage in vogue here permits a back flow of sewage into basements, as Chicago people well know.

Another very useful application of the ejectors is to use them to raise water to tanks on the tops of large buildings, for elevator and domestic supplies. Used in this manner, a Shone plant placed in the basement of any of our large buildings could have its compressor operated by steam from the heating boilers, and could use one ejector to raise all the water needed, while the other could receive all the sewage and expel it promptly and surely from the building to the main sewer. By fixing one of Kaiser's patent counters to the water ejector it answers as a reliable water meter.

The Shone system is in operation at twenty-five cities in England, and has been adopted by the English government and applied for sewering, draining, and ventilating the Houses of Parliament in London.

With regard to the economy of pumping with compressed air, the following table gives the percentage of useful effect that can be obtained in the ejectors for various heads:

Head.	Percentage of Useful Effect.
20	61
40	52
50	49
60	45·5
80	42
100	38·5

From actual diagrams taken from a pair of small steam cylinders, 10½ inches in diameter, compressing air in a pair of 14 inch cylinders to a pressure of 24 pounds to the square inch, which corresponds to a head of 55 feet, 50 per cent. of the total indicated horse power exerted in the steam cylinder has been got in actual work in the ejector.

In the case of sewage pumping engines, the indicated horse power of the steam cylinder is not unfrequently equal to double the power estimated in net weight of water raised, and only under exceptional conditions is the former less than one and a half times the latter.

QUESTION OF EFFICIENCY.

Sanitary engineers, however, should bear in mind that while the efficiencies of engines are ascertained by "indicator diagrams," the efficiency of a sewerage system is determined by the state of the sewers and drains, that in the proportion as these are self-cleansing or otherwise, they are sanitary or unsanitary sewage carriers.

The most economical pumping engine ever designed, fixed at the sewage outfall, will not have the slightest effect on the health of the people if the internal drainage and sewerage arrangements are defective and unsanitary.—*Sanitary News.*

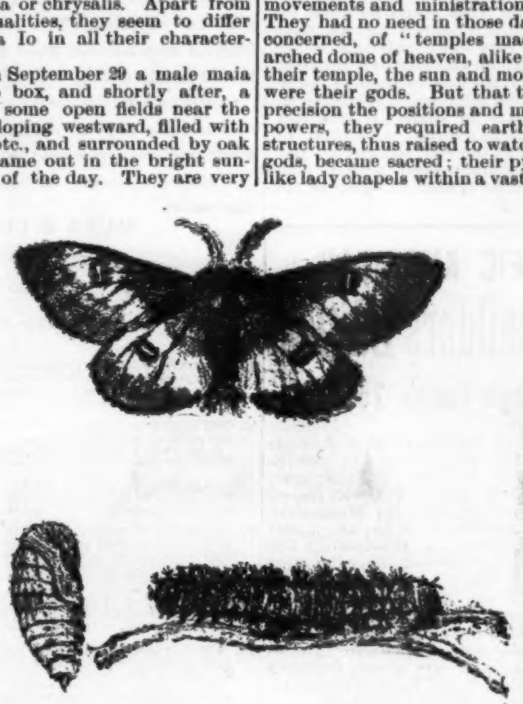
THE SATURNIA MAIA MOTH.

THIS moth, according to Harris, in his work on "Insects Injurious to Vegetation," seems hitherto to have been very rare in Massachusetts. In the summer of 1885 a friend found one of the caterpillars on Blue Hill, Milton, but it died soon after. Later in the season a few moths were seen darting across a patch of scrub oak in the vicinity of the hill, but, their movements being very rapid, and having no net on hand, it was impossible to catch one.

Last summer (1887), near the same locality, between July 3 and August 7 we found seven Saturnia maia caterpillars, four on the wild cherry trees and whortleberry bushes and three on the grass in the woods, under or in the vicinity of whortleberry bushes and low oaks.

They were all well grown when found, and, on being placed in the prepared box, fed and flourished finely. When fully grown they were about 2½ inches long. They were gray and black and white branched spines or prickles on each ring, and small dull orange colored tufts along the back. The head, the first segment, all the feet, and the last segment are of a dull, dark red color. Mr. Abbot in "Insects of Georgia" describes two varieties, but both differ from these. The sting of the spines is very sharp, and like cactus thorns or chestnut burrs; accidentally putting my hand on one, the sting remained for some days and the marks for some weeks. Two caterpillars died, but the rest transformed in the course of a few weeks, one above ground, one half in and half out, and the others underground, from which, however, two of them soon worked out. They spin no covering, but simply change to a plain brownish black pupa or chrysalis. Apart from their size and stinging qualities, they seem to differ utterly from the Saturnia Io in all their characteristics.

To our great surprise, on September 29 a male maia moth hatched out in the box, and shortly after, a great many were seen in some open fields near the woods, especially in one sloping westward, filled with low whortleberry bushes, etc., and surrounded by oak and pine woods. They came out in the bright sunshine of the warmest part of the day. They are very difficult to catch, as they fly very swiftly, doubling on their track, then darting off over the trees and disappearing as suddenly as they appeared.



On Oct. 9 the weather became quite cold, and no more moths were seen. The moths when expanded measure from two and a half to three inches; the wings are much thinner than those of most other moths, and are almost transparent or opaque; they are black, and both pairs are crossed by an irregularly shaped, broad, yellowish white band, covering about a third of their surface; near the middle of this band, on each wing, is a curved, oblong, black spot with a yellow center. The thorax is yellowish white on the fore part, the rest is black, with more or less white dusted in, two dull orange colored spots on the top and several more underneath. The abdomen is black, sprinkled with white, excepting the three last segments, which, in the male, are a brilliant orange. The feet are black, as are also the feathered antennæ. The female resembles it very nearly, but has no orange tip, excepting a few hairs at the extreme end, and the antennæ are narrower. The hair or down on the bodies of both is quite long and thick, especially on the thorax.

No others hatched out in the box, but the two chrysalides above ground are still alive. Whether the confinement did not suit them, or that they are waiting for the spring, and other particulars, have still to be investigated.

H. R. BOWLES.

Poukapoag, Mass., February, 1888.

GOD'S UNIVERSE.

IN old times men looked round upon the earth, seeing there the whole world, the kingdom over which the gods ruled, while in the heavens above they recognized the temple in which their gods abode and were enshrined. There is something strangely impressive in the thought of what earth and heaven must have been to men in those days. We talk of myths doubtingly and coldly, because we cannot readily place ourselves in the position of those who were moved to make myths. We cannot readily picture to our minds what they not only saw, but felt; what—if we consider their position aright—we see they could not help feeling. The grave business man is as unable to recall the fancies of his two year old childhood, and so interpret the feelings of his two year old child, as the more advanced races of man to-day to recall the feelings with which the child man contemplated the mysteries of earth and sun and moon, and the yet more marvelous mystery of the star-strewn heavens. Our school children can at least verbally describe the globe of the earth; they can name the great distance separating us from the sun, and speak of his size and might and power; they can tell how Copernicus and Kepler and Newton explained the strangely seeming movements of the planets. But grown men in old times could not interpret aught they saw. To them the earth's renewal of life year after year was a standing mystery; the sun, as day by day he renewed his victory over the powers of darkness, yet day after day sunk to seeming death in the blood-stained western fields, was as a living, acting, and enduring being, a veritable giant power, rejoicing as a giant to run his course. The moon seemed of set purpose to bear sway over the skies of night, as month after month she returned to full midnight glory, and though she "nightly changed in her circling orb," waxing and waning in power, even in this her individuality and self-power seemed attested. She seemed to measure time for man, as if specially considering his wants. Even more strikingly did the planets, as they pursued

Their wandering course, now high, now low, then hid,
Progressive, retrograde, and standing still,

seem to exercise powerful sway over the destinies of men. It was not merely, as Wordsworth sang, that those "radiant Mercuries"

Seemed to move,
Carrying through ether, in perpetual round,
Decrees and resolutions of the gods,

but that they seemed to be themselves veritable gods. Men watched the movements of those divine beings even as children in Catholic churches watch the entrances and the exits of mitered bishops, robed priests, and surpliced acolytes, recognizing in each a solemn religious meaning, though not knowing what their movements and ministrations may precisely signify. They had no need in those days, so far as worship was concerned, of "temples made with hands," for the arched dome of heaven, alike by day and by night, was their temple, the sun and moon, the stars and planets, were their gods. But that they might note with due precision the positions and movements of these ruling powers, they required earthly structures, and those structures, thus raised to watch the movements of their gods, became sacred; their pyramids and towers were like lady chapels within a vast cathedral, their gnomons and obelisks were as altars or other essential adjuncts of their Sabaistic temples.

Turn, without passing through all the intermediate stages of men's progress, at once from the simple adoration of those older times, when men prostrated themselves bodily before the orbs of heaven, to the teachings of modern science, and it might seem that men had become on the one hand altogether wiser, on the other, altogether less reverent. Think what the earth is to us now in its lessons of a vast antiquity of ever changing aspect, of ever varying forms of life! Consider the infinite depth and solemnity of the tones in which the heavenly orbs speak to man to-day! We are then disposed to smile at the simple, the almost touching ignorance of mankind, during the childhood of their race. Yet, even as the grown man looks back with something of regret upon the fond hopes of youth, and even on the foolish fancies of boyhood and the illusions of infancy, so might the profoundest student of to-day be led to envy former ages their simpler faith, did he not recognize that the universe as we see it to-day, rightly understood, presents a grander and more enduring temple for men, a more wonderful power for their worship, than the men of old times could even have imagined.

Consider the steps by which men passed from their former contented ignorance to their present growing, but ever unsatisfied, thirst for knowledge—noting at every step how the unknown and unexplained seemed ever to be the place of Deity, but that while the unknown was ever passing into the domain of the known and the unexplained into the domain of the understood, men's recognition of the immensity of the unknowable, the infinity of the inexplicable, has been ever growing clearer and more defined—so that whereas once men saw a temple in the skies and deities in the orbs of heaven, the universe itself is now recognized as the temple of the godhead, the power working in and through all things as Almighty Omnipresent—aye, and *Ever-Manifest*—Deity.

First came the recognition that our earth is a globe, and the measurement of that globe's size. The nations of old times had doubtless come to recognize the earth as occupying a large space, for they knew that long distances separated Babylon from Egypt, and either from India and so forth. None of the earlier nations can have doubted that the earth's surface must be measured by millions of square miles, or the equivalent of such spaces in their modes of measurement. Still, the surface they had imagined as belonging to the earth was almost as nothing compared with the 200 millions of square miles which they recognized as forming the surface of the entire globe, even when they had measured but small arcs of it, and surveyed but a minute portion even of the regions known to them. Then the recognition of the fact that this globe-shaped home of the human race is suspended, as it were, in mid space, even if it be considered (as by them it was considered) to be the fixed center of the universe, must have had an impressive effect on the minds of thinking men.

Still all this was as nothing compared with the significance of the demonstration by Copernicus that the earth and the planets form one family, the sun being the center about which they all travel. Because, so soon as this had been accomplished, it became possible to form a clear idea of the relative distances and even some idea of the actual distances of the other planets, and thus to form adequate ideas of the relative importance of those orbs as compared among themselves, and even as compared with the earth. The addition to the universe of five other worlds, probably at least as large (on the average) as the earth, was assuredly a most striking achievement. No wonder if the more narrow-minded among religionists, unable to reconcile such a discovery with the limited ideas they had formed of the might and wisdom of the Deity, shuddered with horror at the daring of the Copernicans in imagining (nay, in even venturing to prove) that there may be other worlds than ours.

Even this, however, was in turn but nothing when compared with the discovery of the real meaning of the stars, following almost immediately on the recognition of the real nature of the planets. Tycho Brahe, who was moved with something like indignation against the doctrines of Copernicus, pointed out at once that if they were true, every star must be an orb of enormous size and splendor, perhaps comparable even with the sun, which he regarded as preposterous. For, said he, our earth could not circuit in this immense orbit which the fond Copernicans assign to her, without causing the constellations to change entirely in aspect in the course of each year. In autumn or winter, for instance, we look at the constellation Orion from a position many millions of miles away from that which we occupy when we look at that constellation in spring. Hence the star groupings would present an entirely altered appearance, unless we are to imagine that such a distance as 100,000,000 of miles (the real distance is 186,000,000 of miles, but Tycho Brahe did not know that) counts for nothing as compared with the distances of the stars. But if so, if they really lie at distances which must be measured by thousands of millions of miles, we need only remember that our sun removed to such distances would look no larger than a star, to see that we must regard the stars, manifestly self-luminous as they are, as veritable suns, if this pernicious Copernican theory is admitted.

When Kepler and Newton had established the Copernican theory on altogether irrefragible evidence, and when the telescope enabled men to measure the planets, still grander ideas about the universe began to force their way into men's minds. It was seen that Jupiter and Saturn are very much larger than the earth, and are the centers of systems of subordinate worlds. With increasing accuracy in the estimates of the sun's distance, it was seen that all the planets are farther off, and therefore larger, than had been supposed. It became, in fine, certain that the earth is not the chief member of the family of worlds attending upon the sun.

But this was nothing compared with the amazing significance of the selfsame telescopic teachings in regard to the stars. Not only did every increase in the estimate of the sun's distance increase in corresponding degree men's estimate of the stars' distances, but every increase in the power of estimating position made clearer and clearer the apparent fixity of the stars, and therefore threw them, as it were, farther and farther back into the abysses of space. It had been wonderful enough that the eye could detect no relative displacements among the stars as the earth circled in her wide orbit around the sun. But it presently became clear that, even with the immense increase in the power of determining positions which the telescope gave to astronomers, no sign of change could be detected during the year in the position of any star. Bradley attacked the problem, but though he worked so well that he was able to detect the annual change due to the aberration of light and the nutation (or nodding motion) of the earth's axis, he discovered no annual displacement. The best astronomers in Great Britain and on the Continent attempted the task and failed. At length astronomers gave up hope, beginning to regard the stars as, all and severally, too far removed to afford appreciable evidence of displacement as the earth revolved in her wide orbit around the sun.

But just when success was despaired of, a double success was secured. Henderson at the Cape of Good Hope recognized the measurable annual displacement of the bright star Alpha Centauri; while Bessel at Konigsberg recognized a smaller yet measurable displacement of the faint star (barely visible to the naked eye) numbered 61 in the constellation of the Swan. (Bessel had chosen this faint star for observation because it is moving much more rapidly on the star sphere than its fellows, as if it were relatively near the earth, so that its motion, though not really greater than that of other stars, appeared greater through the effects of proximity.) But when at last the problem had been mastered, when for the first time the actual distances separating us from the stars, and the stars from each other, came to be recognized, how tremendous those distances were found to be! The nearest of all the stars in the heavens lies twenty millions of millions of miles from us, in such sort that light speeding with a velocity of 187,000 miles in a second takes more than three years in coming to us from that star. Our sun removed to the same distance would appear but as a star—nay, he would be a very much smaller star, in appearance, than that nearest of all our neighboring suns.

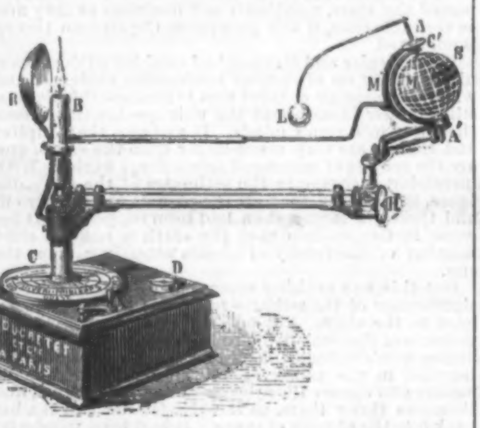
But in the meantime, while one set of astronomical researches was showing astronomers the immensity of stellar distances and the sunlike character of every star, another set of researches had shown and was showing the vastness of the numbers of the suns within our galaxy. The thousands of suns visible to the naked eye had increased to hundreds of thousands in the days even of Galileo. Another century had shown astronomers that the stars within telescopic range must be counted by millions. Sir William Herschel's gauges of the star depths had shown that our estimate of the numbers of the stars must run into tens and even hundreds of millions. And to-day it is well known

that if the most powerful of the telescopes made by man could be used in surveying every portion of the heavens, the total number of stars which would be brought into view would far exceed one thousand millions. The increase with each increase of telescopic power has, moreover, taught the lesson that we can in no sense limit our estimate of the number of stars by the number which even our most powerful telescopes would show. If we could double the space-penetrating power of our telescopes, we should probably much more than double, we should increase manifold, the number of stars—that is of suns—which would be brought within our ken. Not thousands of millions, but probably millions of millions, of suns exist within the limits of the sidereal system. Rather—I ought to say—they exist within the limits of our sidereal system, for doubtless this system is no more to be regarded as single within the universe than our solar system is unique within the star depths. Every star tells us of a sun, and probably of a solar system, in such sort that we must recognize thousands of millions of solar systems in the galaxy. May we not fairly assume, then, that in like manner our sidereal system is repeated millions of millions of times within some system of a higher order? That system may be in turn repeated many millions of times within a system of a higher order. And so on, to higher and higher orders, absolutely without end.

Recognizing this as the teaching of the astronomy of to-day, and noting how great to us appears the earth itself, though she is but the first step in an evergrowing series, each successive term of which enormously surpasses the preceding, we cannot but perceive that it is infinity, not mere vastness, with which we have to deal: "End is there none to the universe of God; lo, also, there is no beginning."—*Knowledge.*

THE GIROD COSMOGRAPH.

WE illustrate a new form of cosmograph lately introduced to the educational world. The study of the science of cosmography, at once so useful and agreeable, offers great difficulties, because the movements of the heavenly bodies are too complicated to be exactly represented by geometric figures. The result is that most students only obtain an imperfect idea of the movements even of the earth and moon in their orbits, and the different phenomena resulting from the respective positions of these orbs often are not understood,



GIROD'S COSMOGRAPHIC APPARATUS.

even after the best lessons. Different pieces and styles of apparatus have been devised for facilitating the task of the teacher. Some of the more complicated represent the movements of all the spheres composing the planetary system; others are simpler, and illustrate only one or two special phenomena, giving no idea of the whole.

By the Girod apparatus an appeal is made to the intellect at the same time as to the eyes. By proper manipulation, the apparatus reproduces the revolutions of the earth and of the moon around the sun, thus giving a complete representation of all the phenomena consequent on these rotations. The movements of the other planets, and of their satellites, are so analogous to those of the earth and moon that an idea of their motions can be also obtained from the one apparatus.

The machine in general consists of the following parts: A candle, B, represents the sun. A reflector, R, is used to intensify its rays, projecting them upon the terrestrial sphere, S. The sphere, S, representing the earth, is carried by two rods. At their outer extremity is a vertical horary circle, H. The axis, A A', around which this sphere rotates is constantly vertical to the same plane, making an angle of 66° 36' with the plane of the ecliptic. A half meridian circle, M, always parallel to the same plane, marks the sidereal day; another half meridian, M', whose plane constantly passes through the sun, marks the solar day. A sphere of smaller size, L, represents the moon. On the base is a compass, D, to orientate the apparatus.

On a solar dial, C, are marked days and months, with the degrees passed over by the earth in its movement around the sun, together with the seasons, equinoxes, solstices, and signs of the zodiac. Around this dial a needle travels, indicating the positions of the earth referred to the sun. The elliptic outline of the dial represents the general character of the orbit of the earth in its revolutions around the sun. A lunar dial, C', over which also an index travels, tells the different phases of the moon.

The apparatus is about two feet in diameter, and is mounted on a box containing the wheelwork. Upon the upper surface of this box a crank, N, is seen. By this the apparatus is worked.

A mere list of the phenomena that the apparatus can illustrate would occupy much space. The cause of the seasons and of the inequality of days and nights, of apogee and perigee, and of the long polar day and night, are shown. The obliquity of the plane of the ecliptic, and the different aspect of the constellations at different times, are explained. The distinction between the sidereal and solar day is shown. The phenomenon of twilight and variation in right ascension and declination of the sun, and the difference of time, with all the ordinary phases of terrestrial movements, are provided for. Both solar and lunar eclipses can be illustrated by it.

The moon and her movements are also explained: its vibrations and its sidereal and synodic rotations. With one or two exceptions, inevitable from the small size of the instrument, the astronomical features are all presented accurately.

ANCIENT MICROSCOPES.

MR. FRANK CRISP, LL.B., secretary of the Royal Microscopical Society, recently lectured upon "Ancient Microscopes," of which he exhibited a hundred or two collected from all parts of the world. He said that they served to illustrate the ignorance and incompetence of the ancients, which was no more than might have been expected, considering the dark ages in which our forefathers lived. They made their microscopes of paper, parchment, ivory, tortoise-shell, and other such materials. One of the microscopes before them once belonged to Cardinal Lambertini, afterward Pope, who lived in the fourteenth century; he also exhibited another microscope made for one of the Popes by an Englishman; it was decorated, he remarked, with barbaric splendor. He likewise exhibited two which had been the property of George III. He exhibited ancient European microscopes, also some of Chinese and Japanese make. One of the latter had no lenses, nor any place left for lenses. With most of the ancient instruments on the table, he said no work had been done of sufficient value to come down to the present time; indeed, with some of them no work could be done, for they were built on the principle of houses in earthquake countries, that is to say, of very light materials, so put together that they would fall on the slightest provocation; he then upset some of the microscopes by blowing at them. One more recent microscope exhibited by him resembled a bent poker in shape; it was constructed to go down a patient's throat, and then, by means of a little glow lamp at the end, to light up portions of the interior of the human body, so that they could be seen by the aid of the system of lenses in the instrument.

HAIR TONIC.

DR. FOLEY, in discussing the tonic treatment of the hair (*New York Med. Jour.*), states that the end sought in building up a scanty crop of hair is a proper amount of blood supply, through friction and hair tonics. The following is an excellent hair tonic:

℞ Carbolic acid, ½ drachm; tinct. nux vomica, 2 drachms; tinct. cinchona, 1 ounce; tinct. cantharides, ½ drachm; Cologne water and cocoanut oil, of each sufficient to make a 4 ounce mixture. Apply once or twice a day to the scalp by means of a soft sponge.

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